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(12) **United States Patent**
Hamada

(10) **Patent No.: US 7,935,054 B2**
(45) **Date of Patent: May 3, 2011**

(54) **MINIMAL ACCESS LUMBAR DISKECTOMY INSTRUMENTATION AND METHOD**

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(73) Assignee: **K2M, Inc.**, Leesburg, VA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1108 days.

(21) Appl. No.: **11/230,420**

(22) Filed: **Sep. 19, 2005**

(65) **Prior Publication Data**

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Related U.S. Application Data

(60) Continuation-in-part of application No. 11/165,295, filed on Jun. 22, 2005, which is a continuation-in-part of application No. 11/001,628, filed on Nov. 30, 2004, now Pat. No. 7,173,240, which is a division of application No. 10/280,624, filed on Oct. 25, 2002, now Pat. No. 6,849,064.

(51) **Int. Cl.**
A61B 1/32 (2006.01)

(52) **U.S. Cl.** **600/233**; 600/219; 600/225; 600/232

(58) **Field of Classification Search** 600/233, 600/219, 232, 224, 225, 231
See application file for complete search history.

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(57) **ABSTRACT**

A minimal incision maximal access system allows for maximum desirable exposure along with maximum access to the operative field utilizing a minimum incision as small as the METRx and Endius systems. Instead of multiple insertions of dilating tubes the design is a streamlined single entry device to avoid repetitive skin surface entry. The system offers the capability to expand to optimum exposure size for the surgery utilizing hinged bi-hemispherical or oval working tubes applied over an introducer obturator which is controllably dilated to slowly separate muscle tissue. Deeper end working and visualization areas with maximum proximal access and work dimensions are provided to makes the operative procedure safer in application and shorten the surgeons's learning curve because it most closely approximates the ability to use open microdiskectomy techniques. a dual frame system enables full or partial spreading of a working tube set, while an open frame facilitates a four point retraction system.

15 Claims, 20 Drawing Sheets

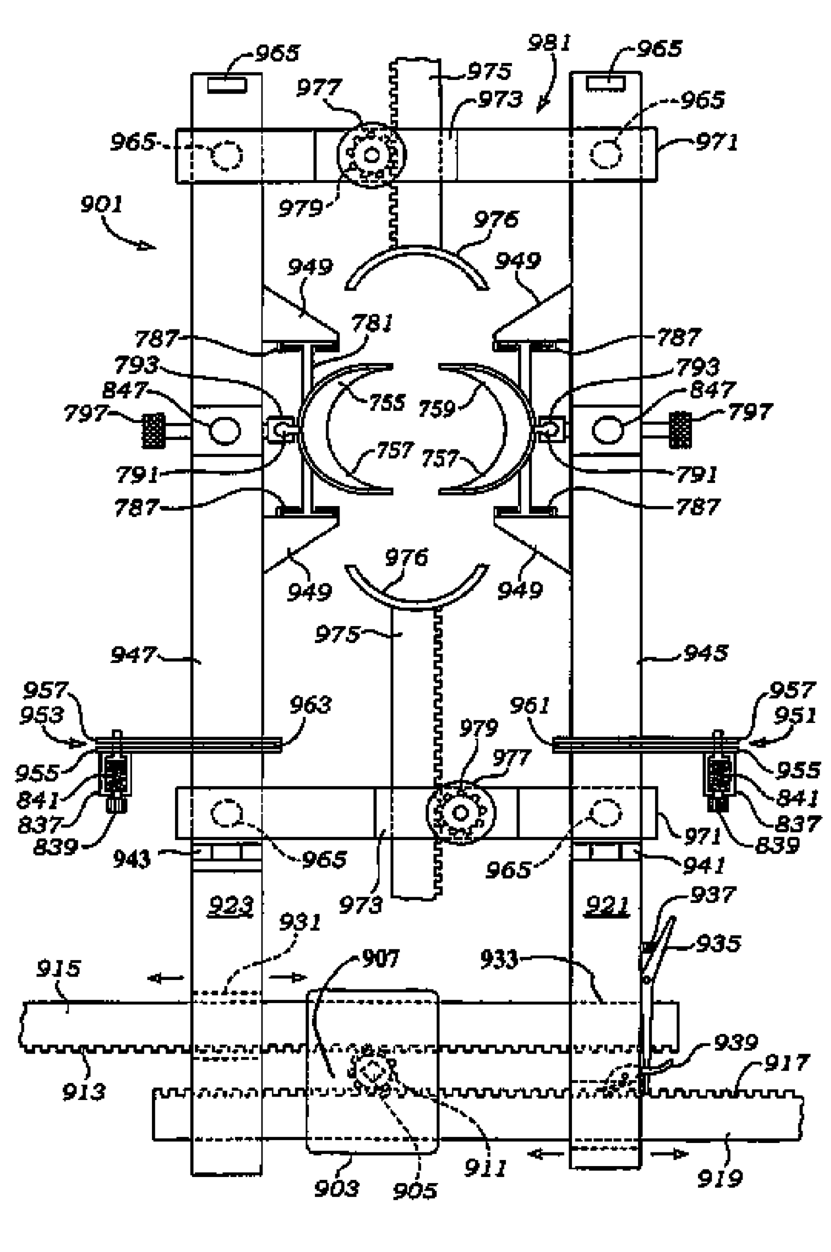

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Fig. 1

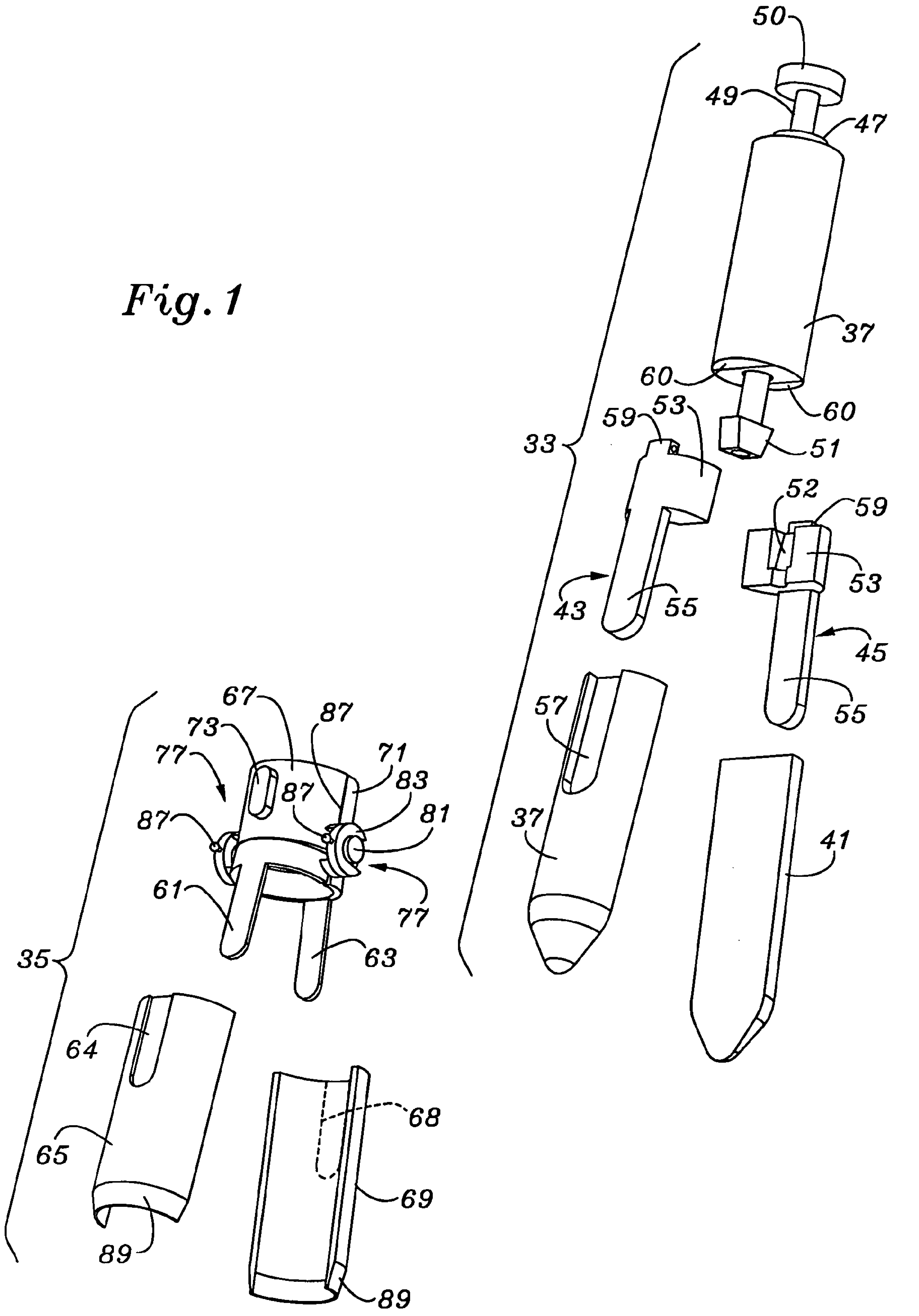
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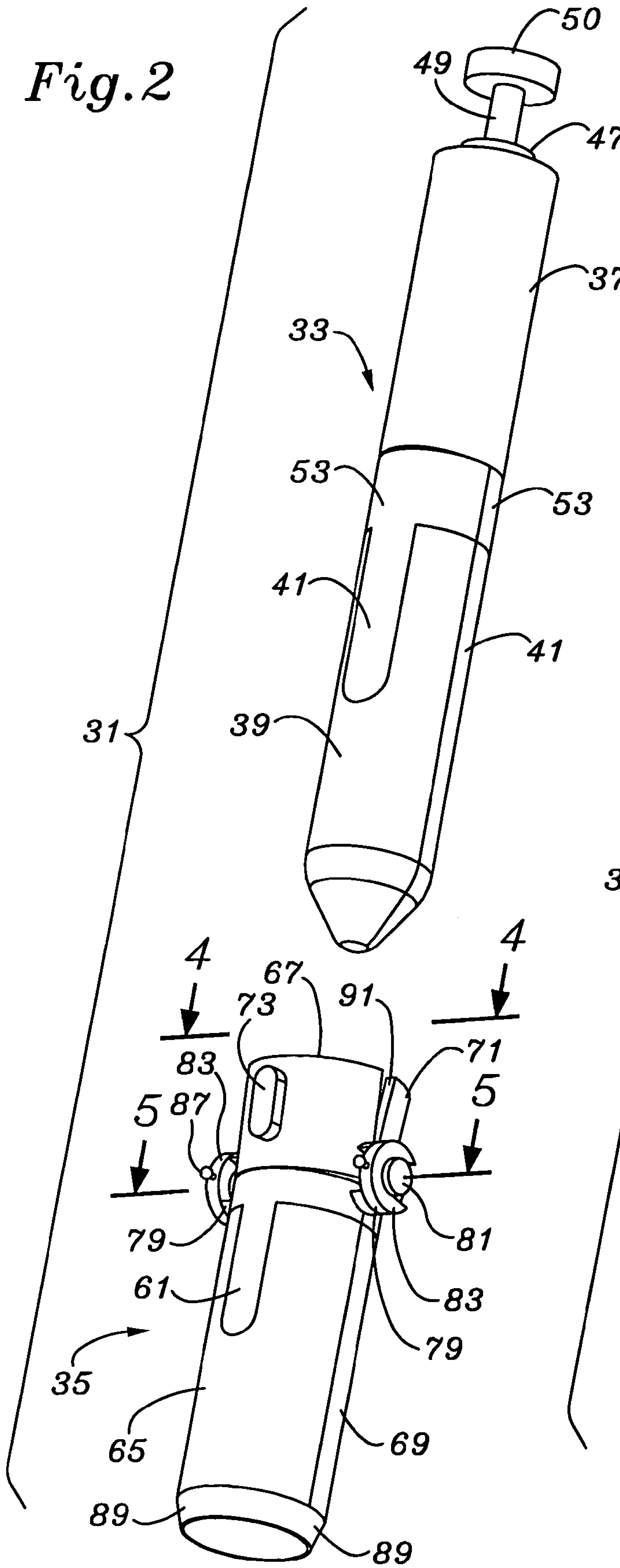
Fig. 2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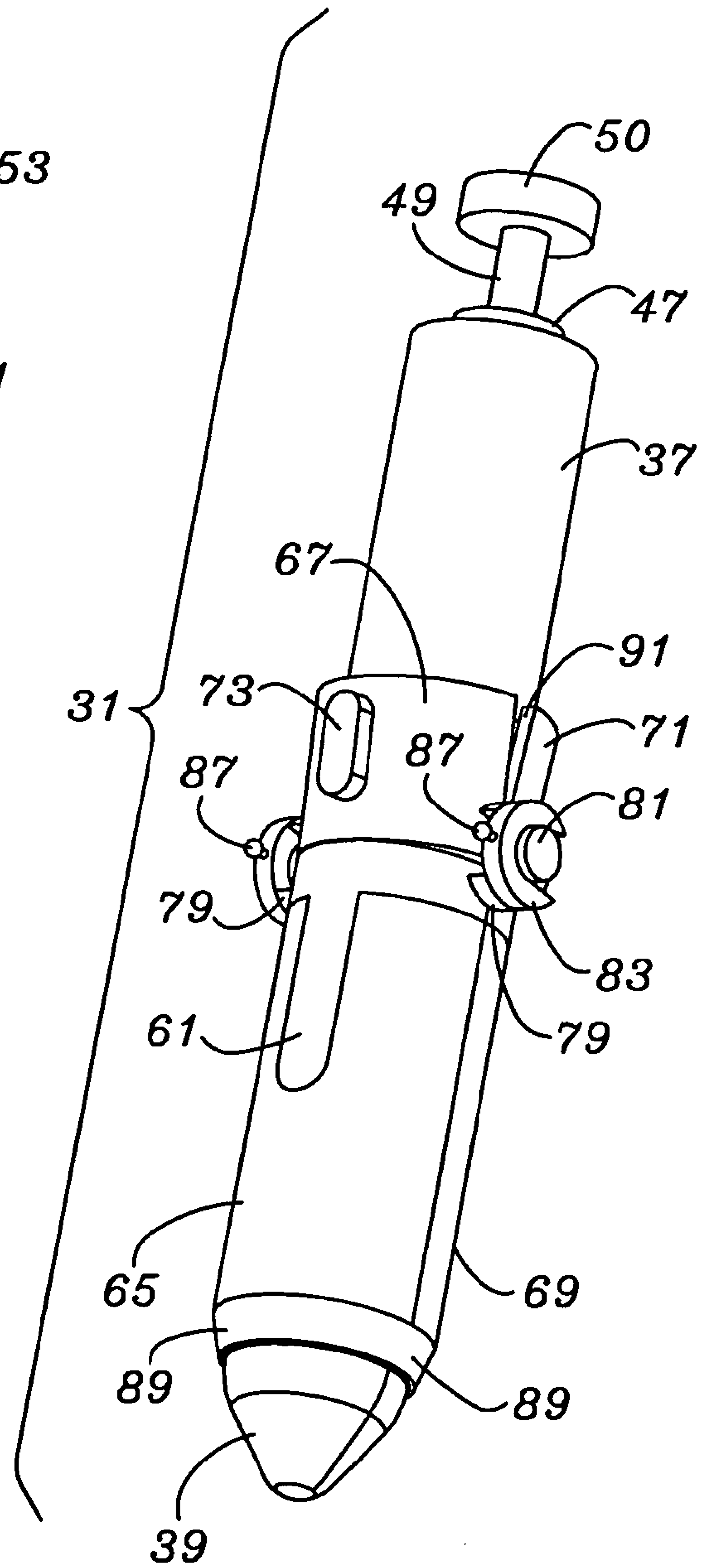
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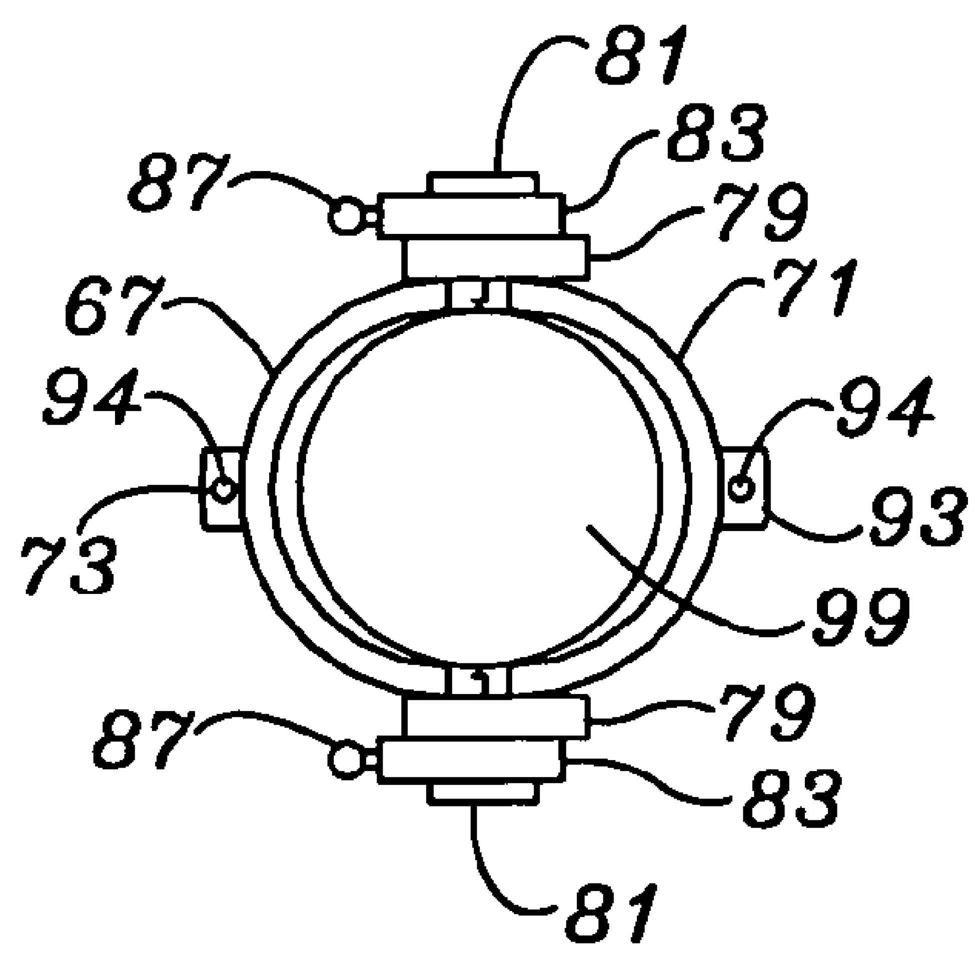
Fig. 4



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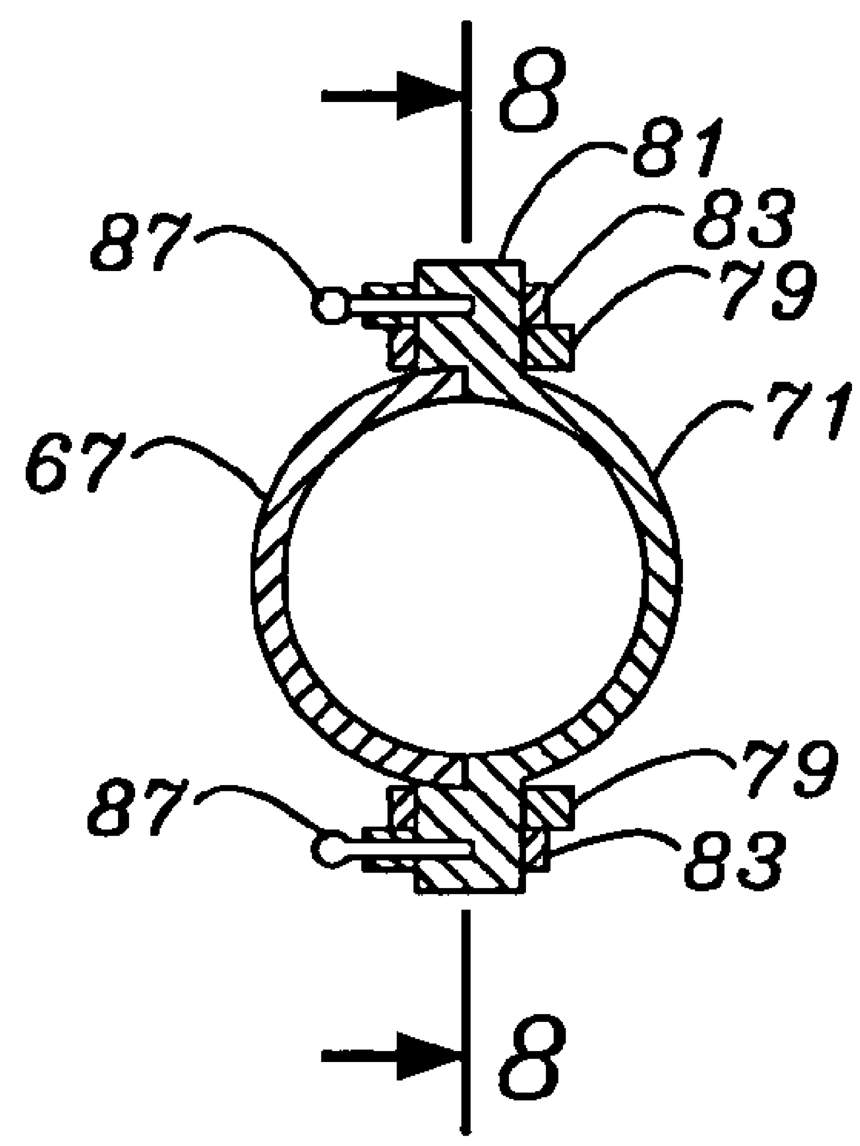

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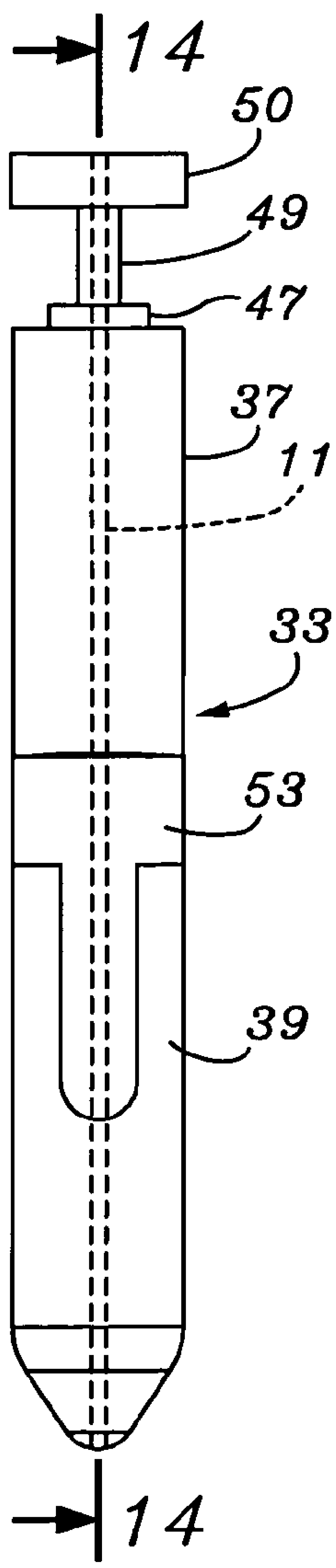

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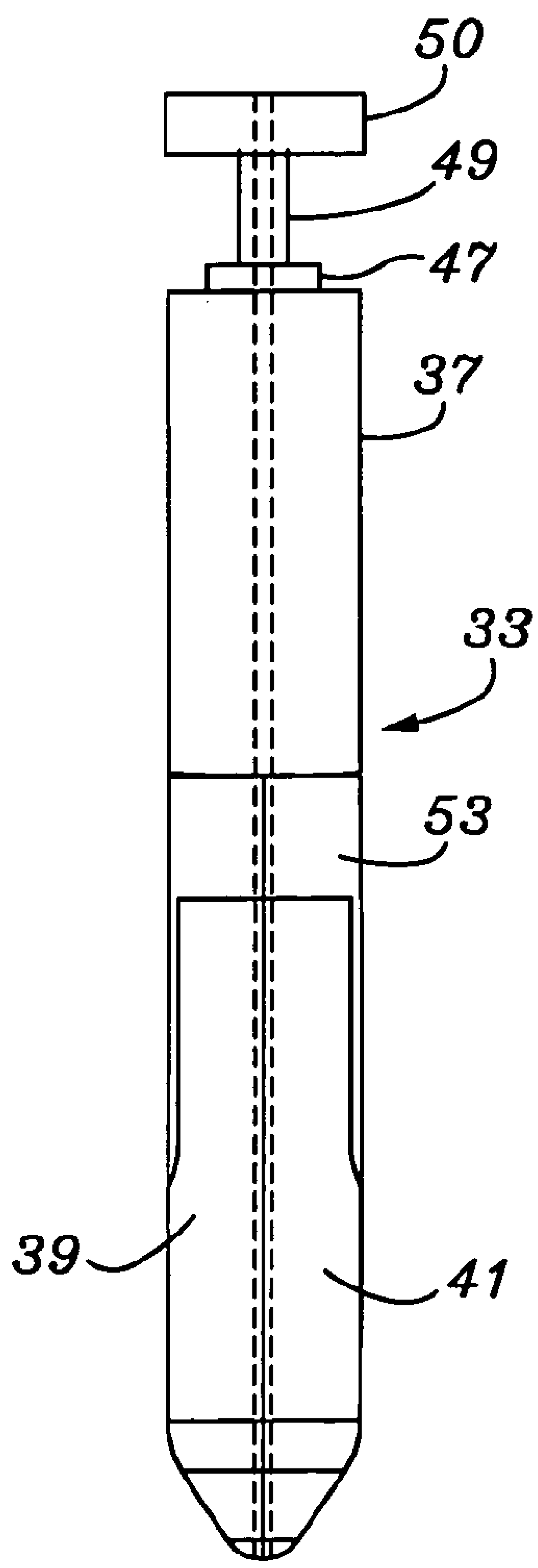

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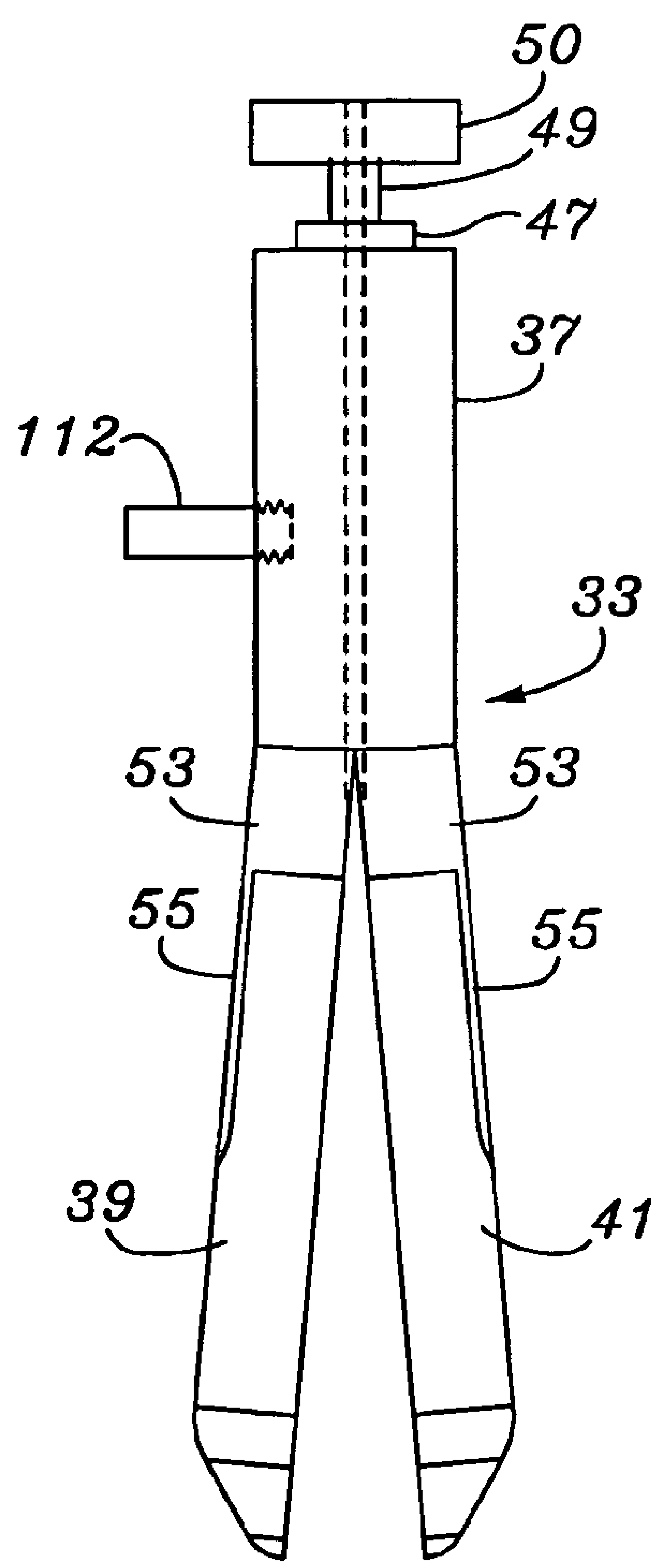

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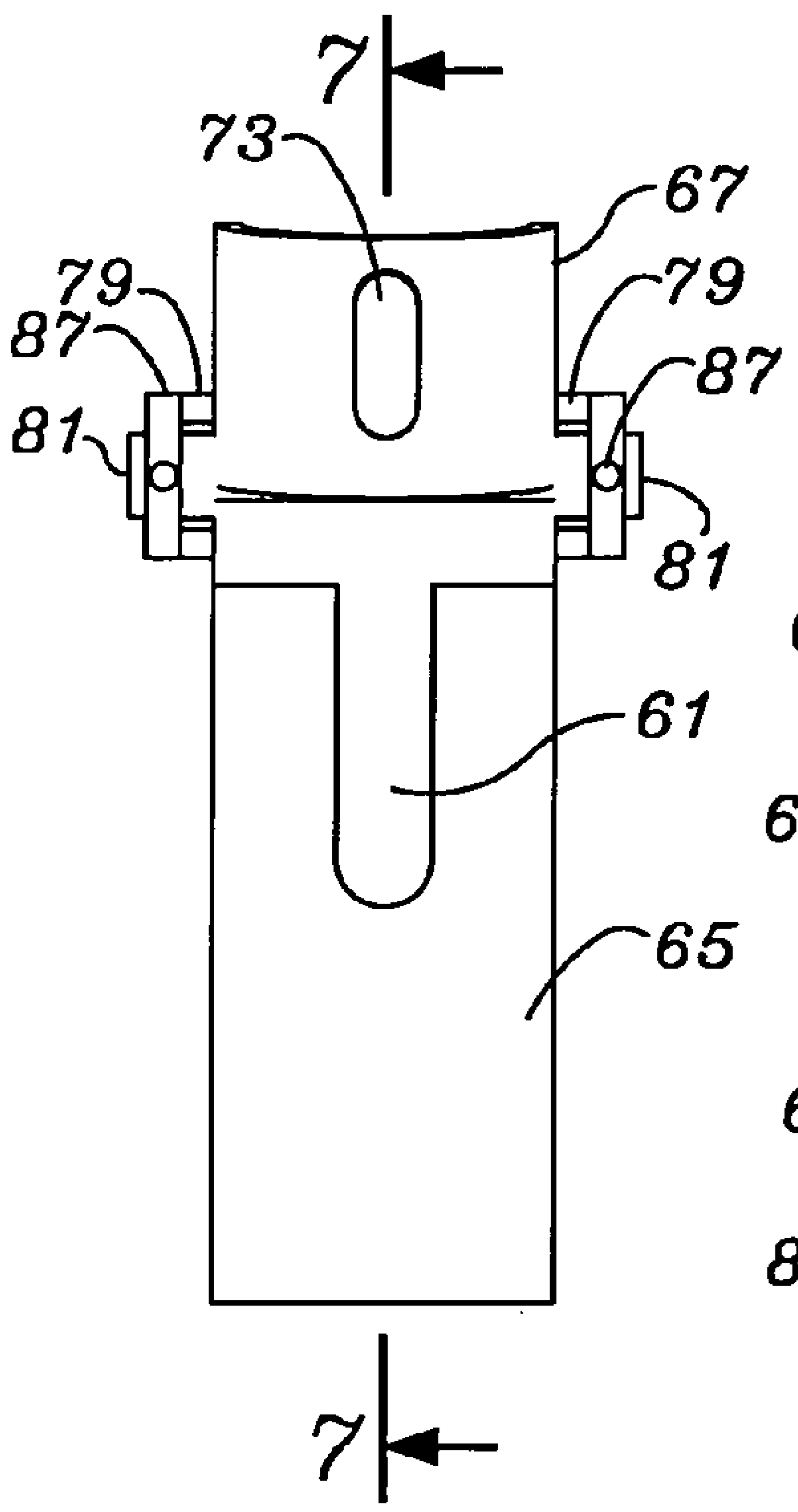

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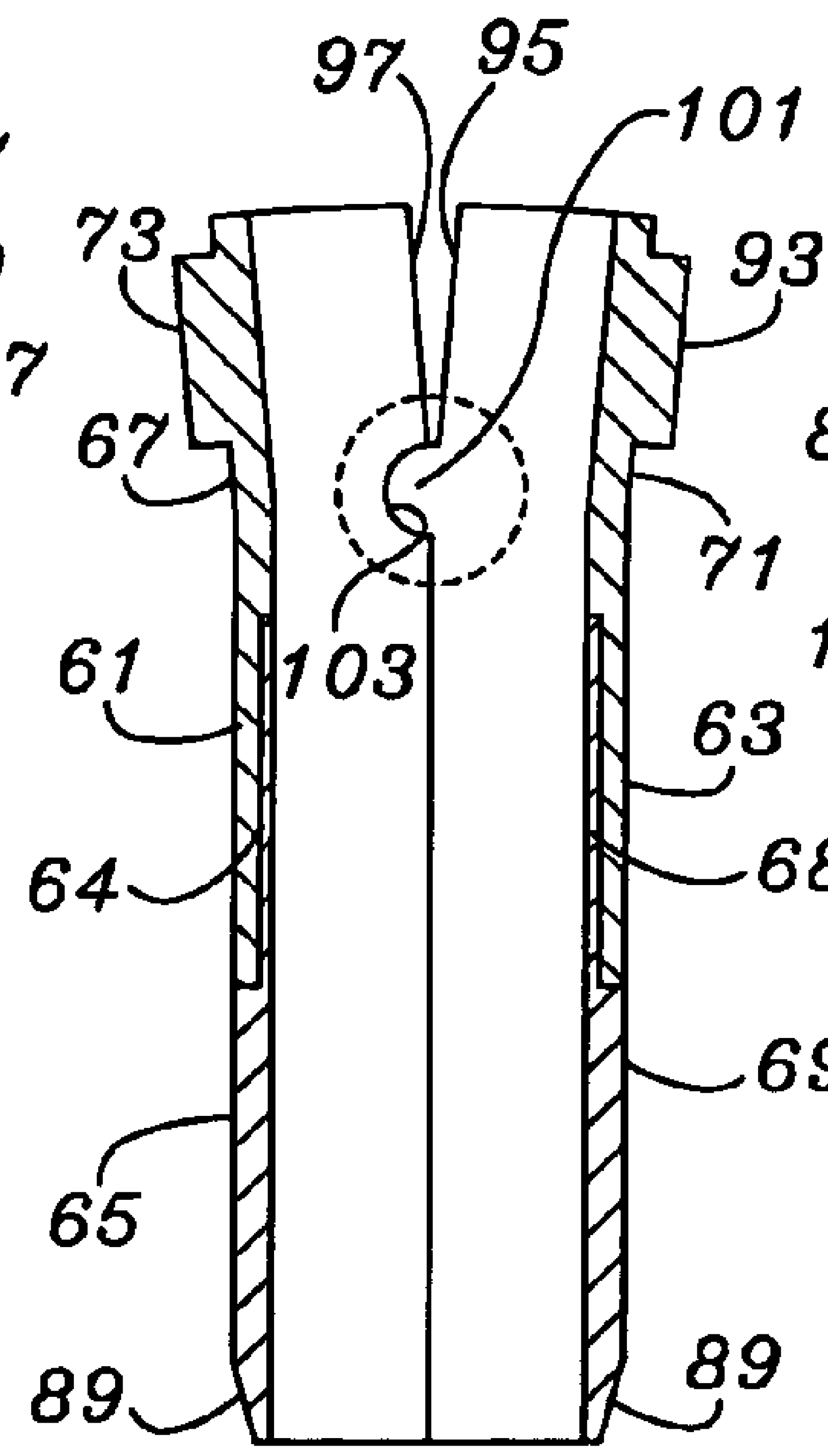

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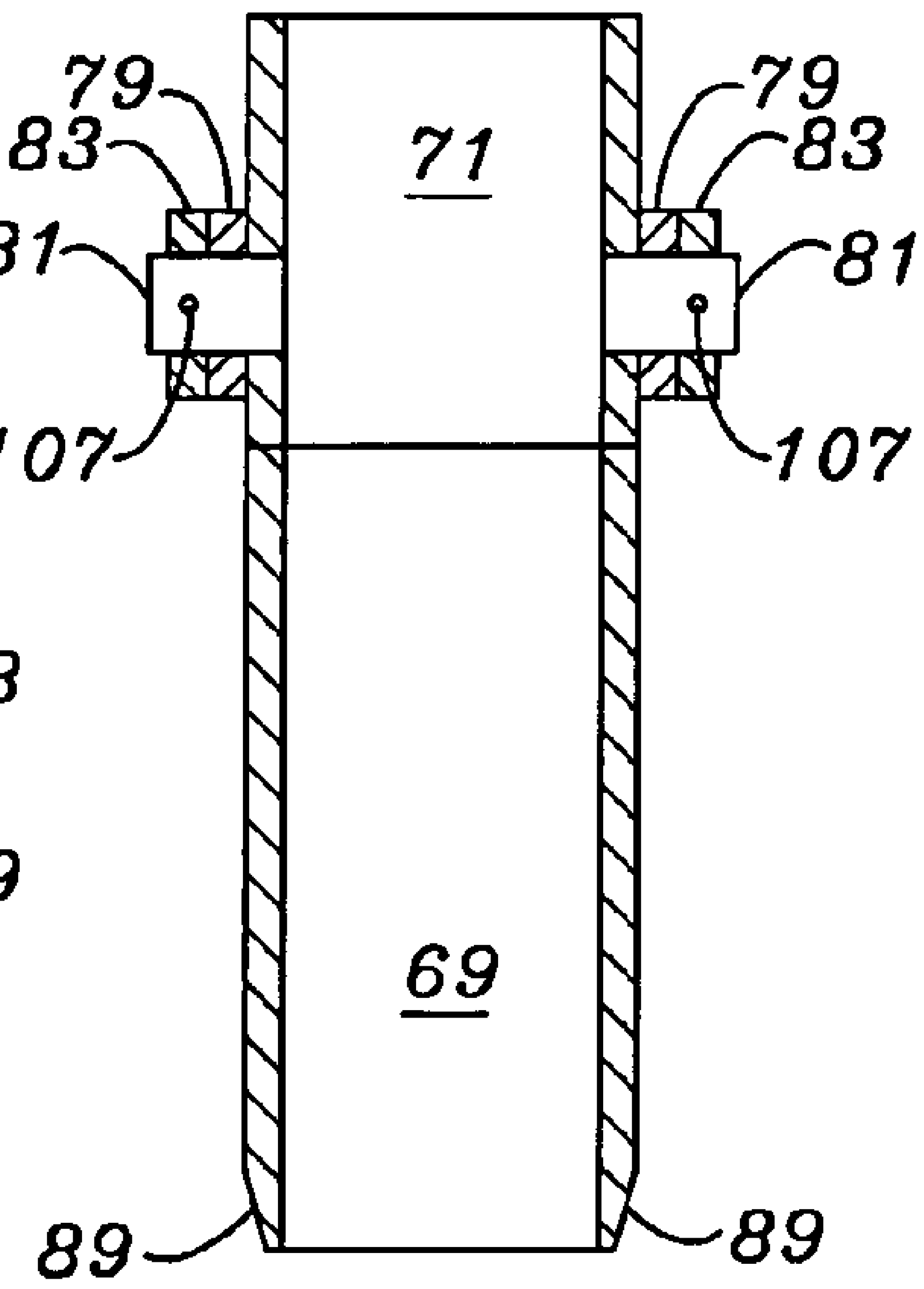

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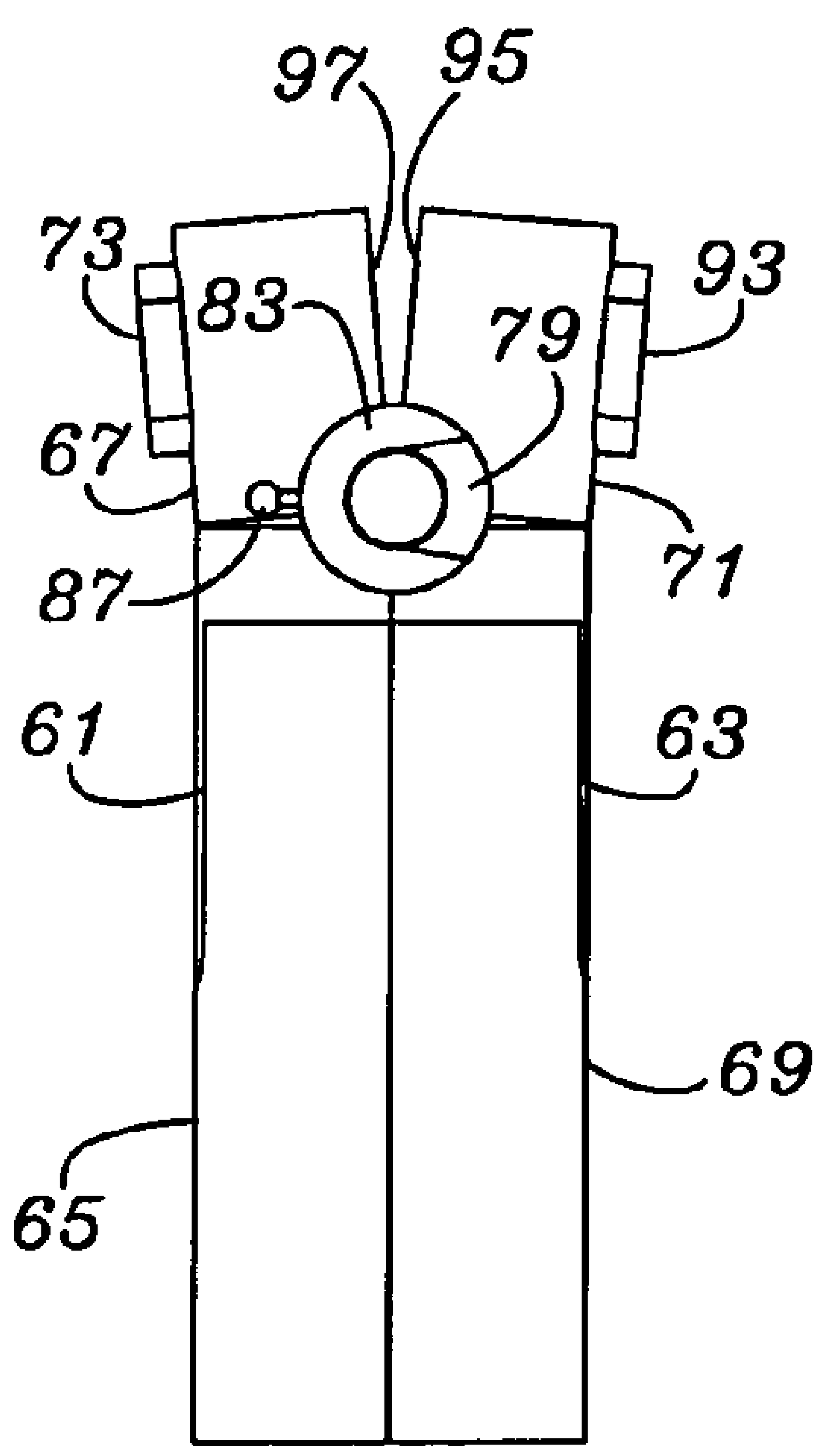

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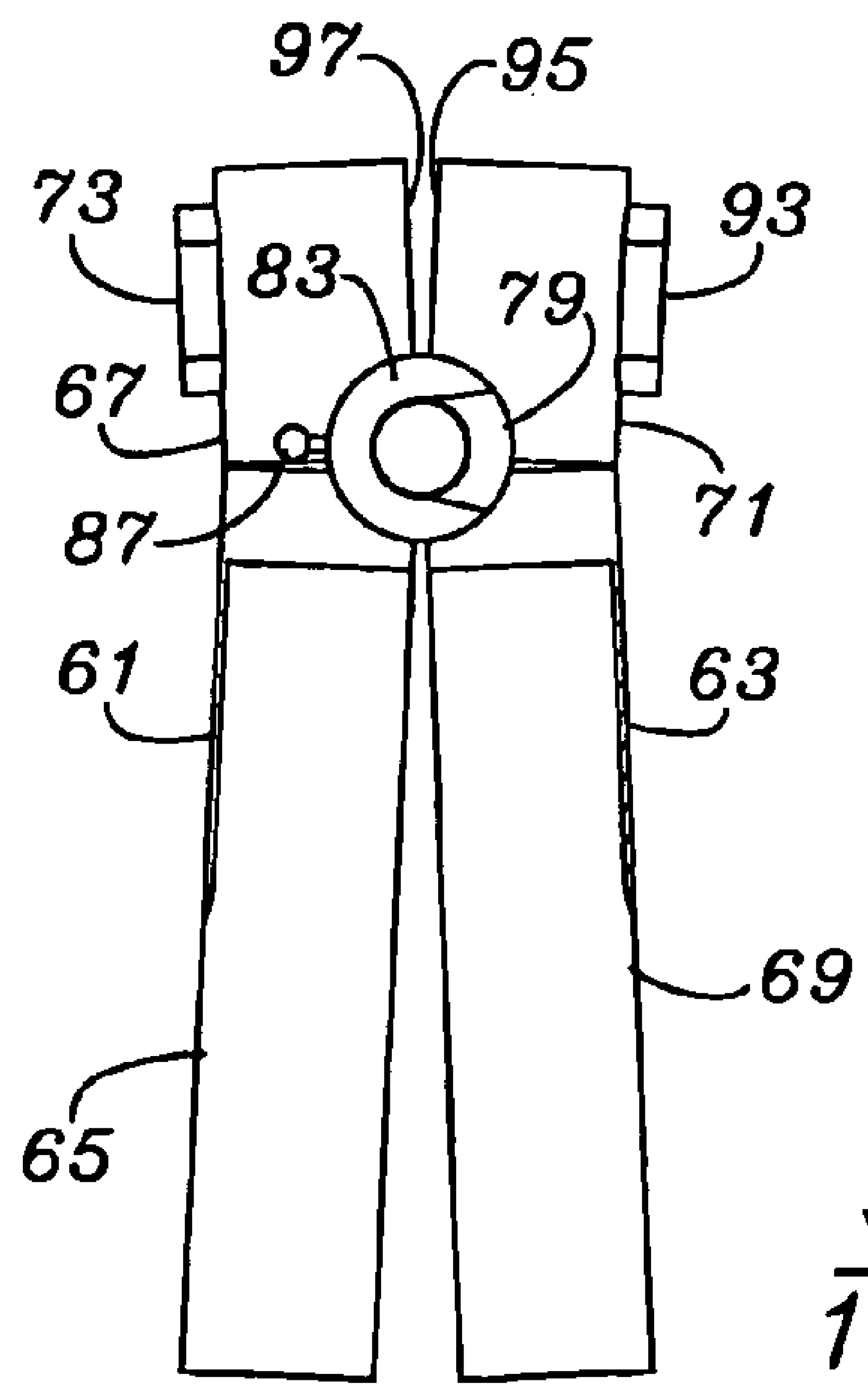

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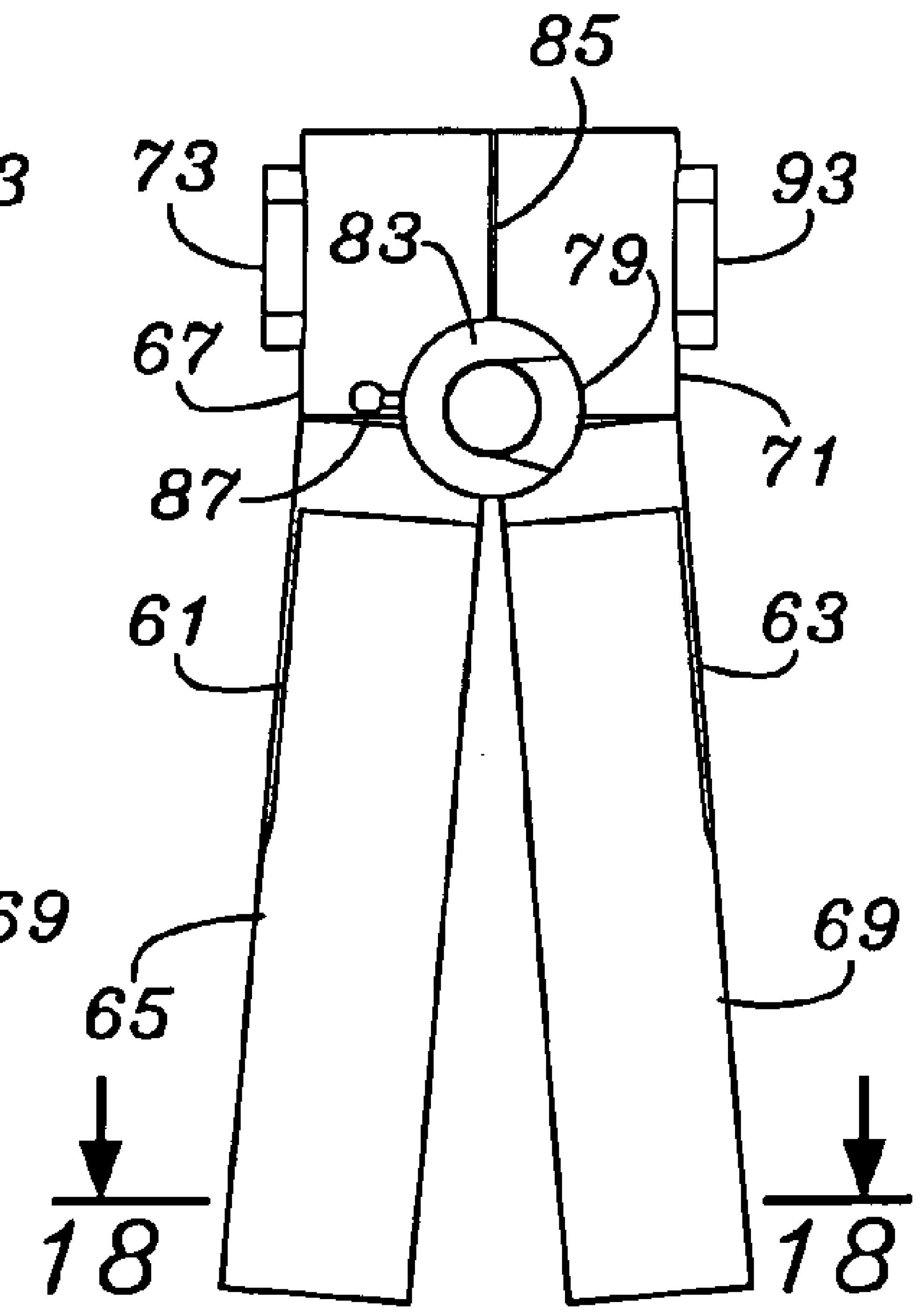

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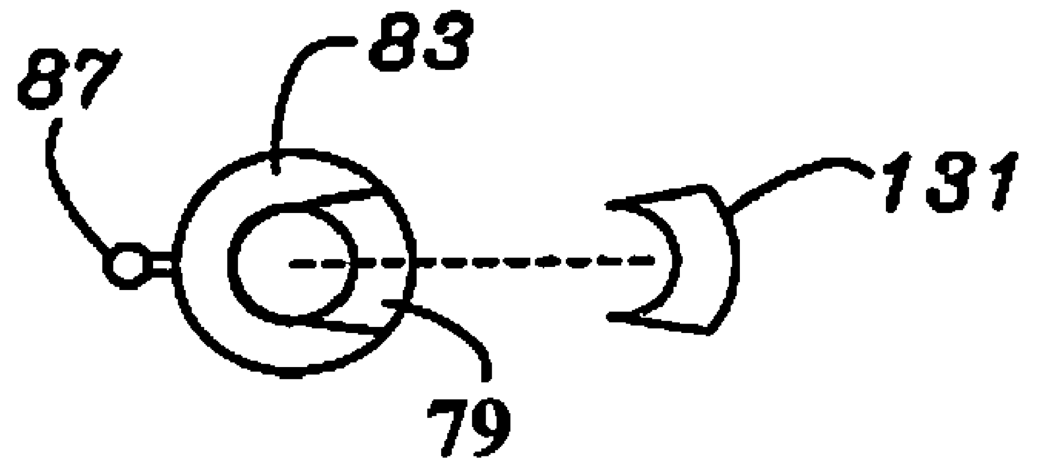

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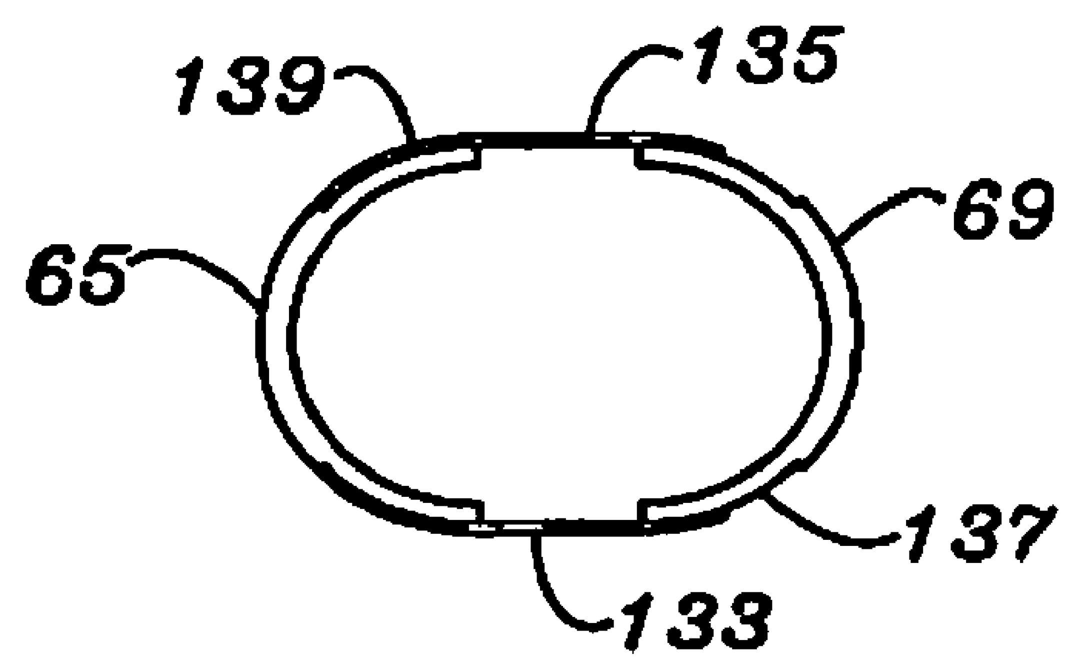

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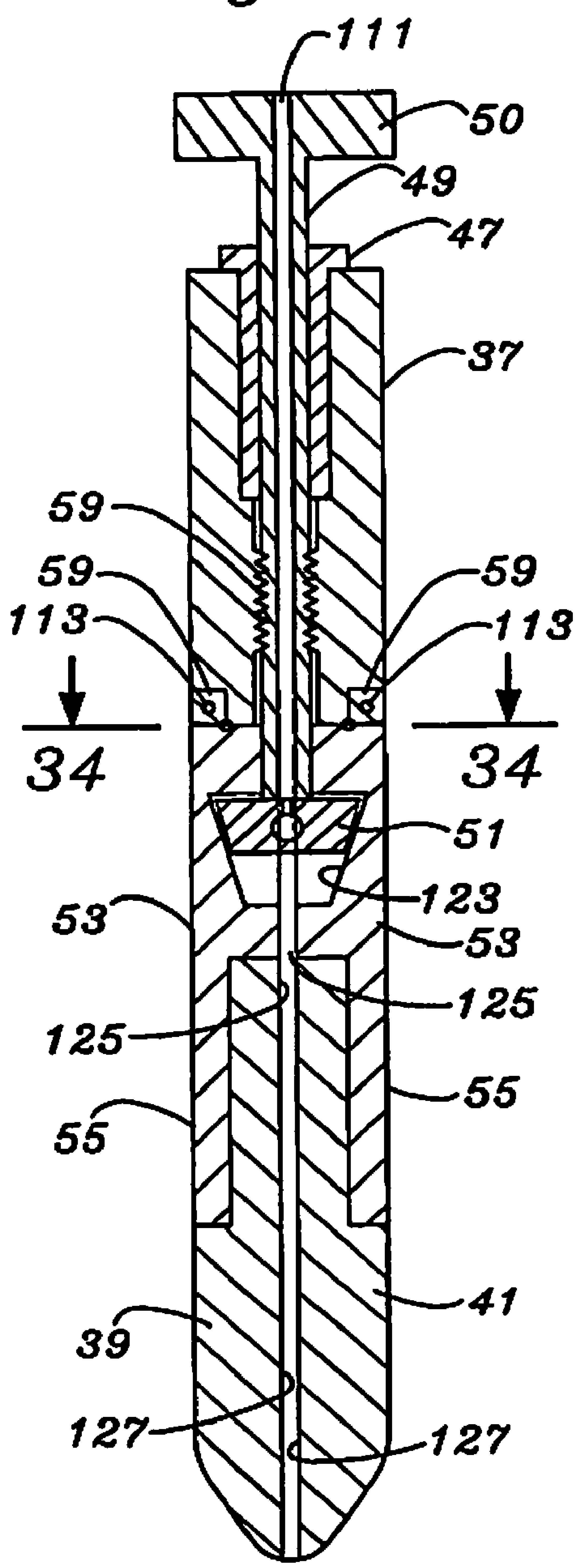

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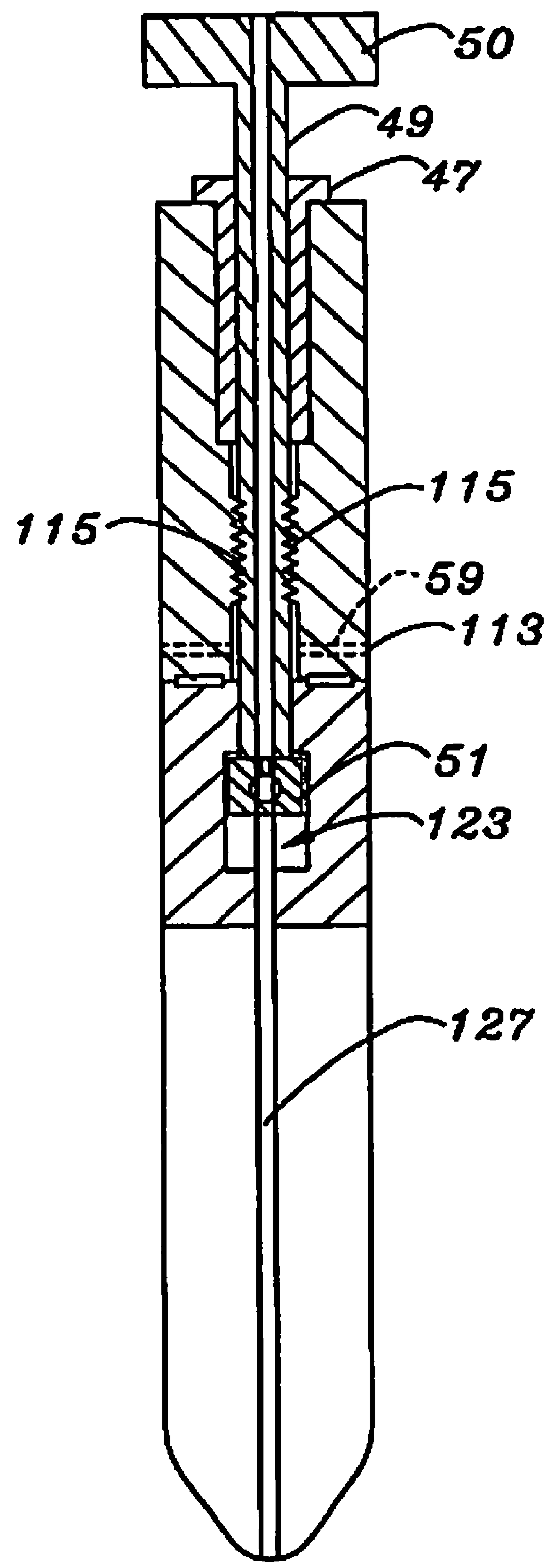

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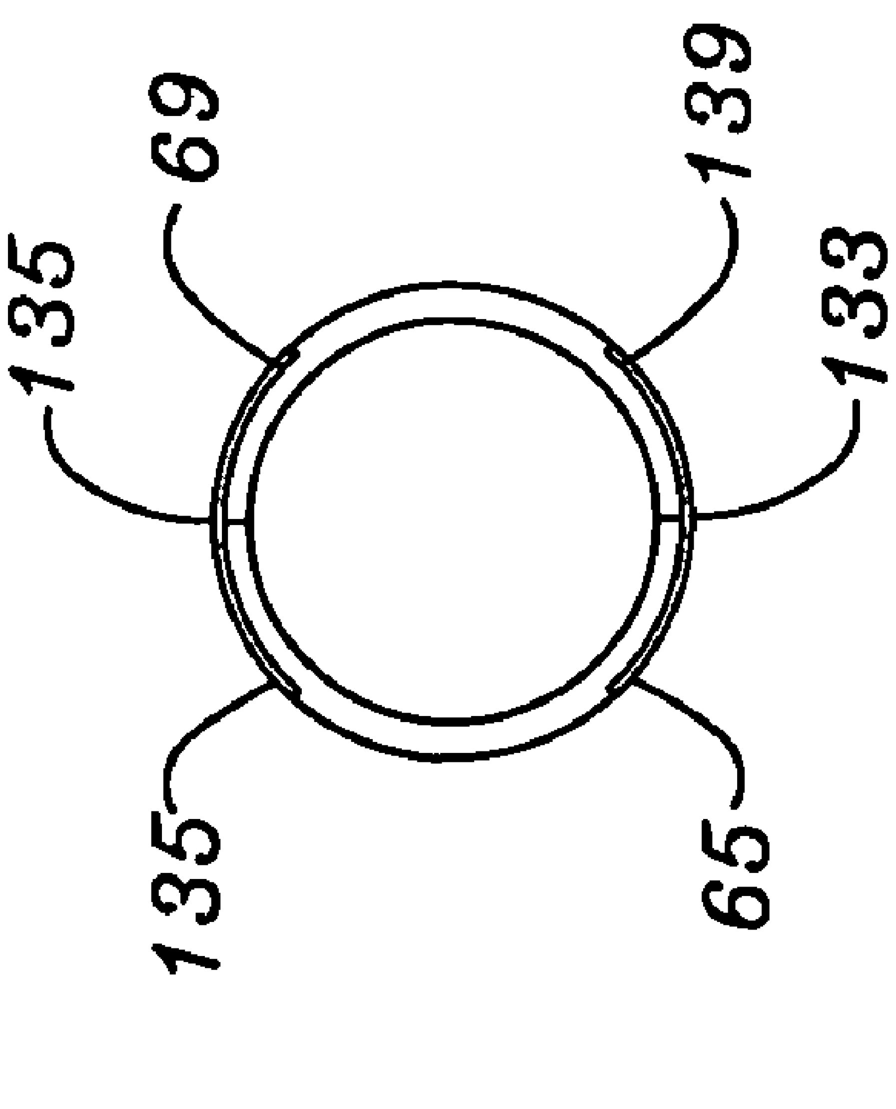

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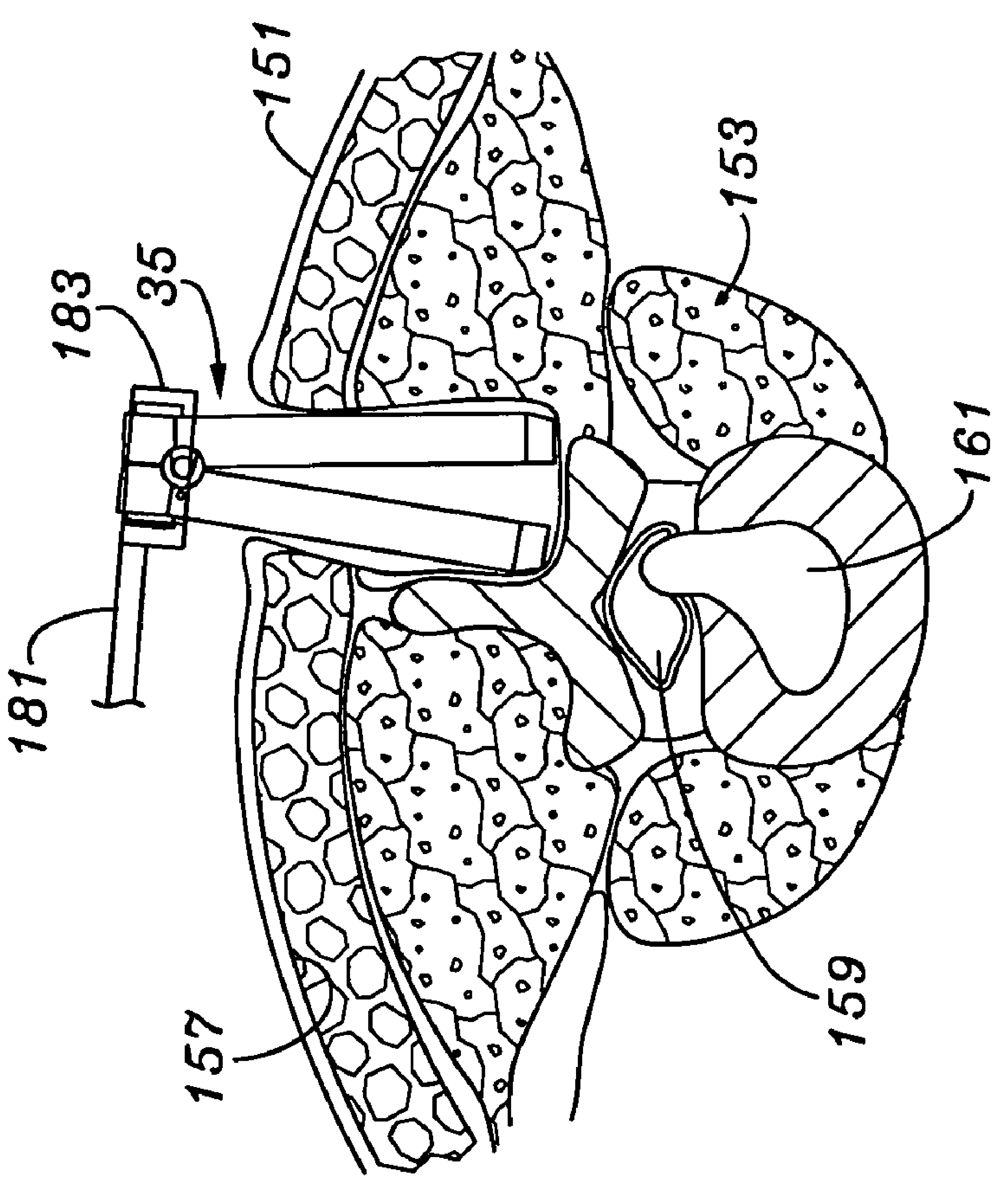

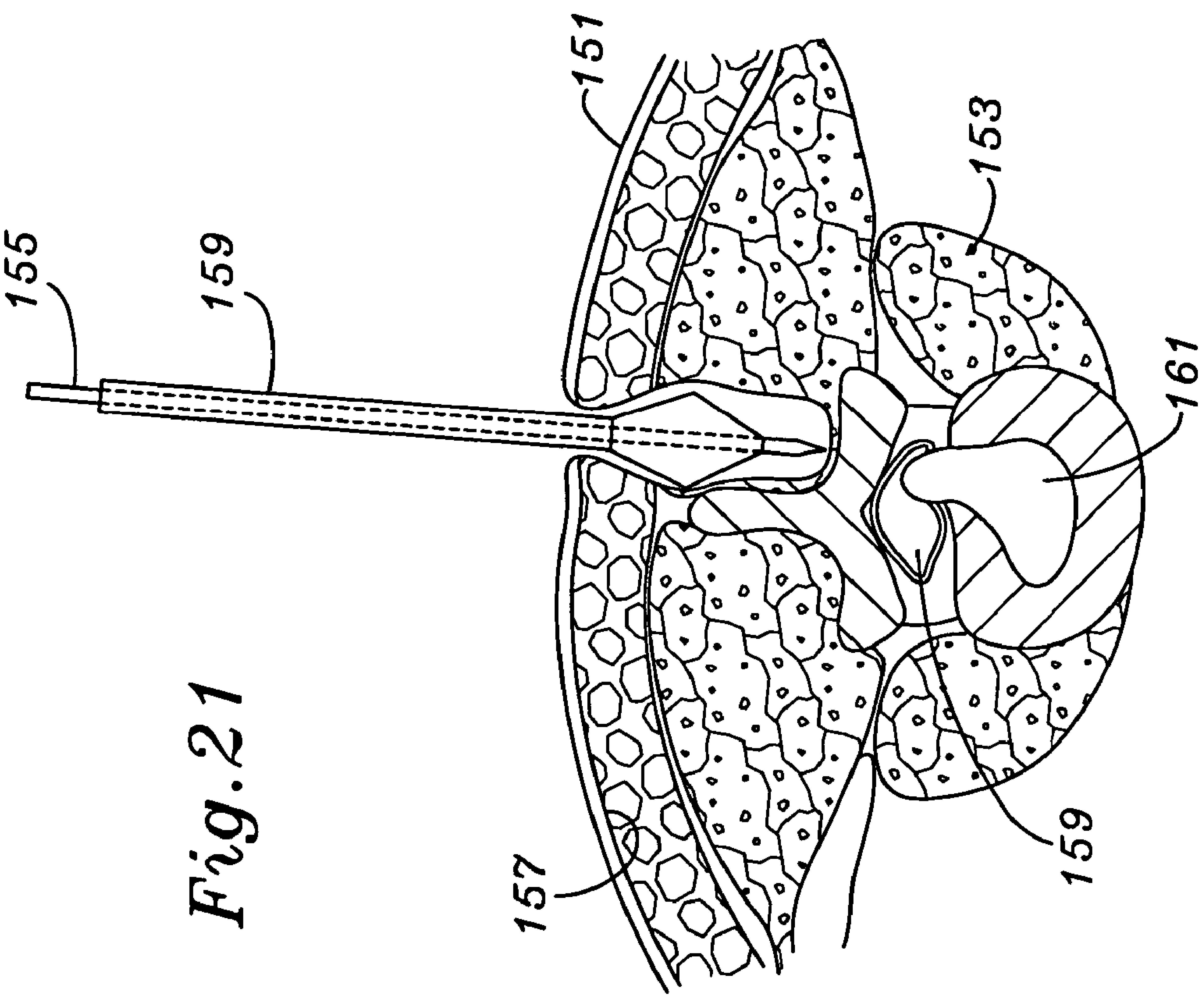

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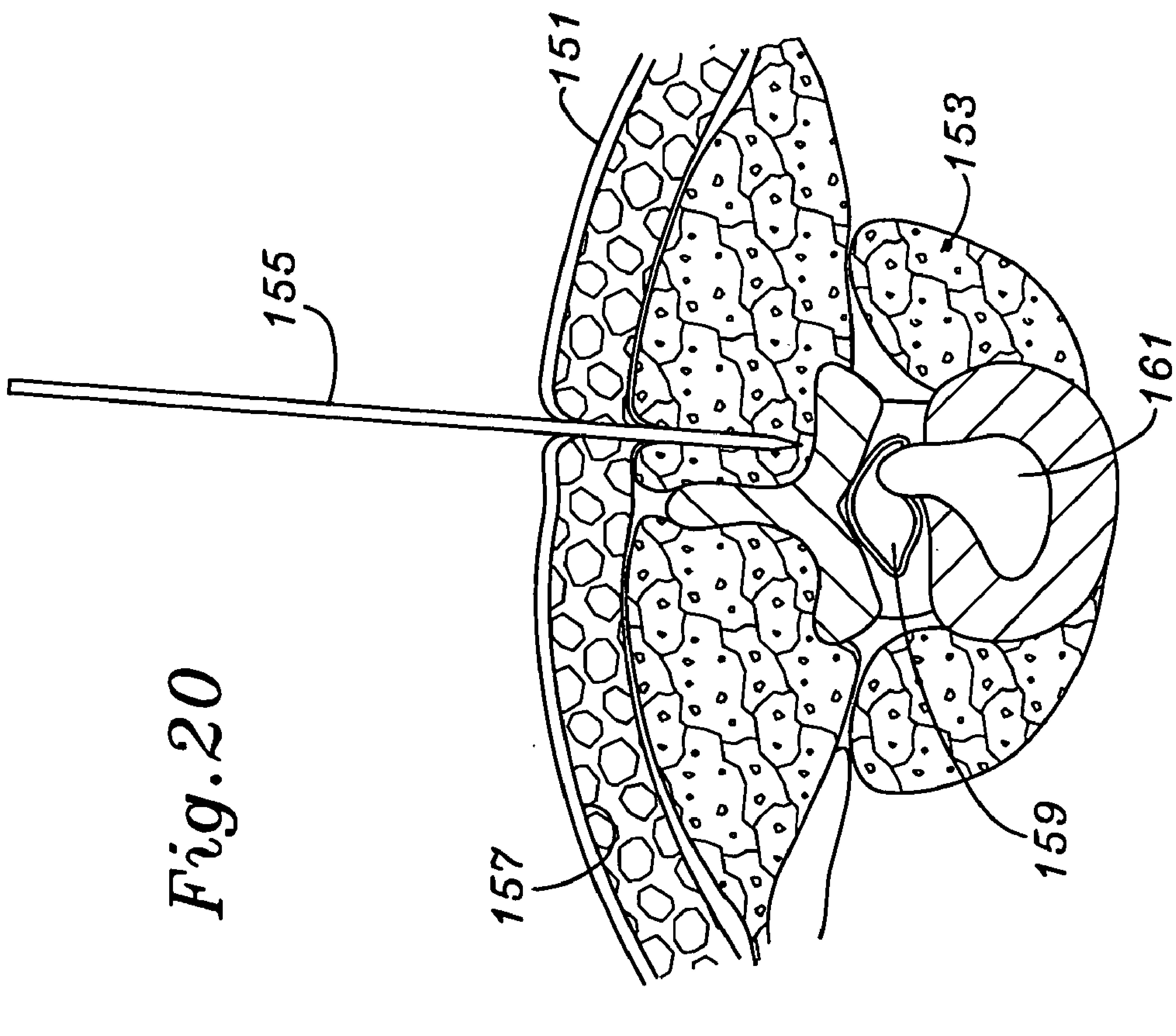

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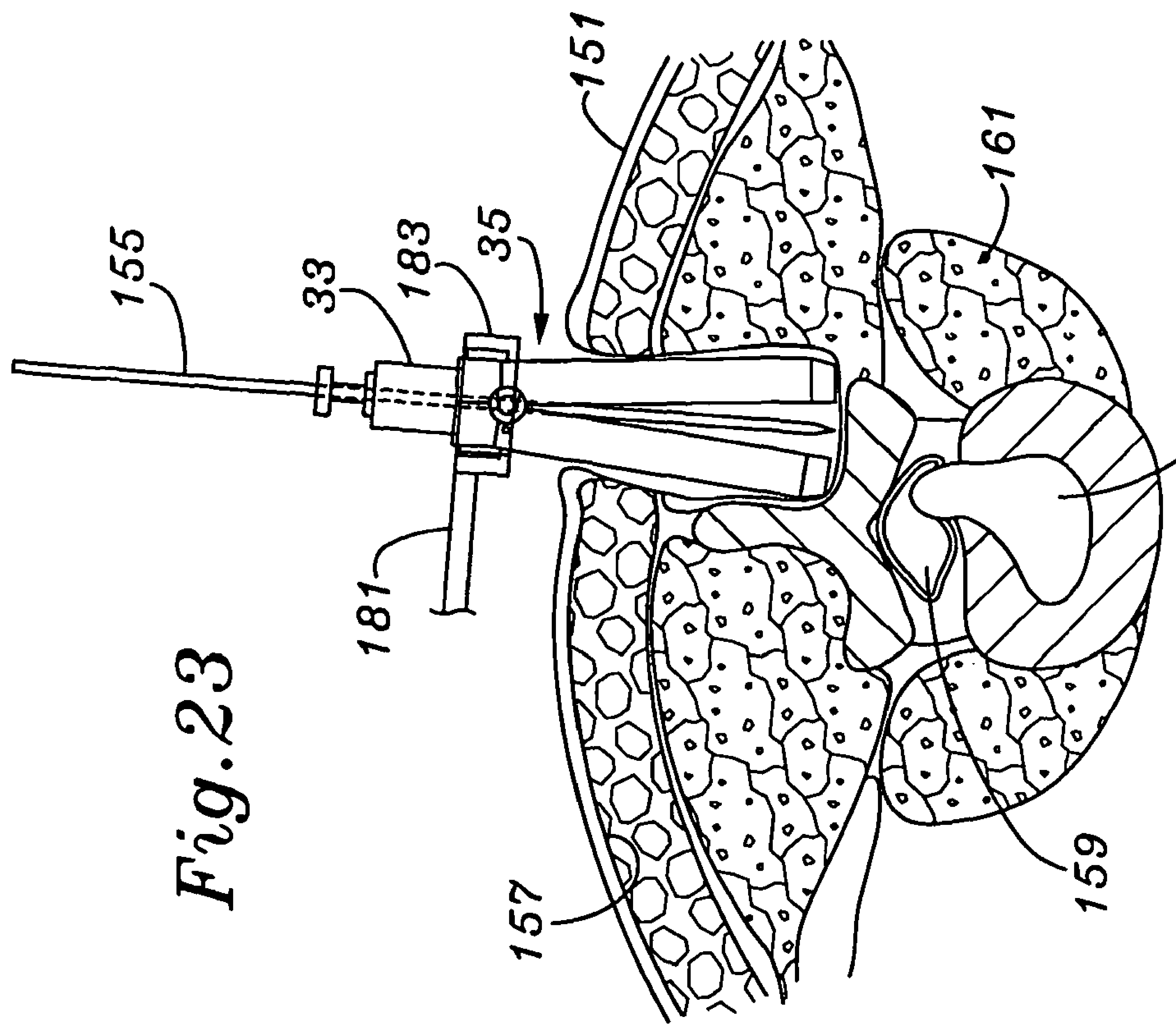
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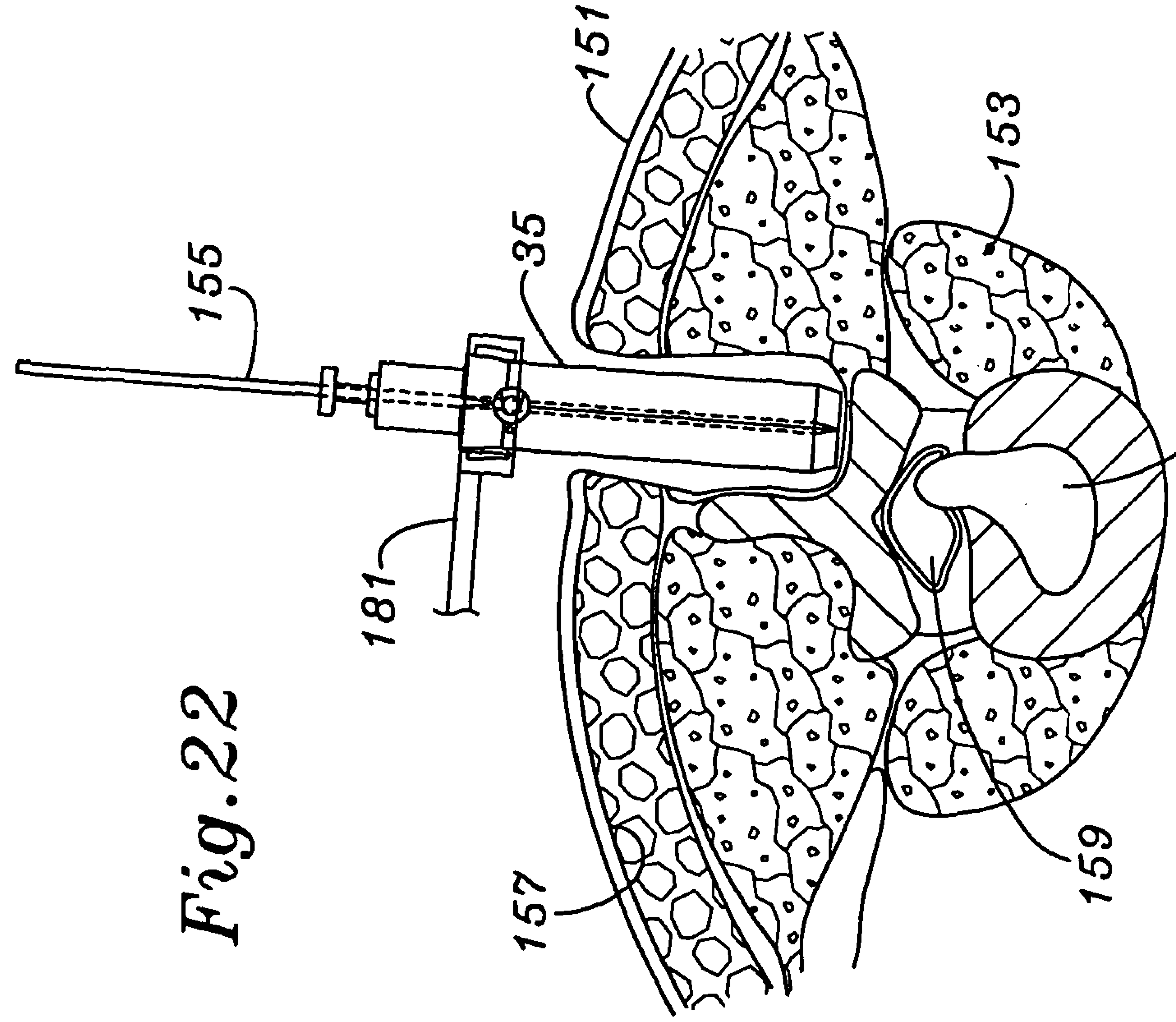
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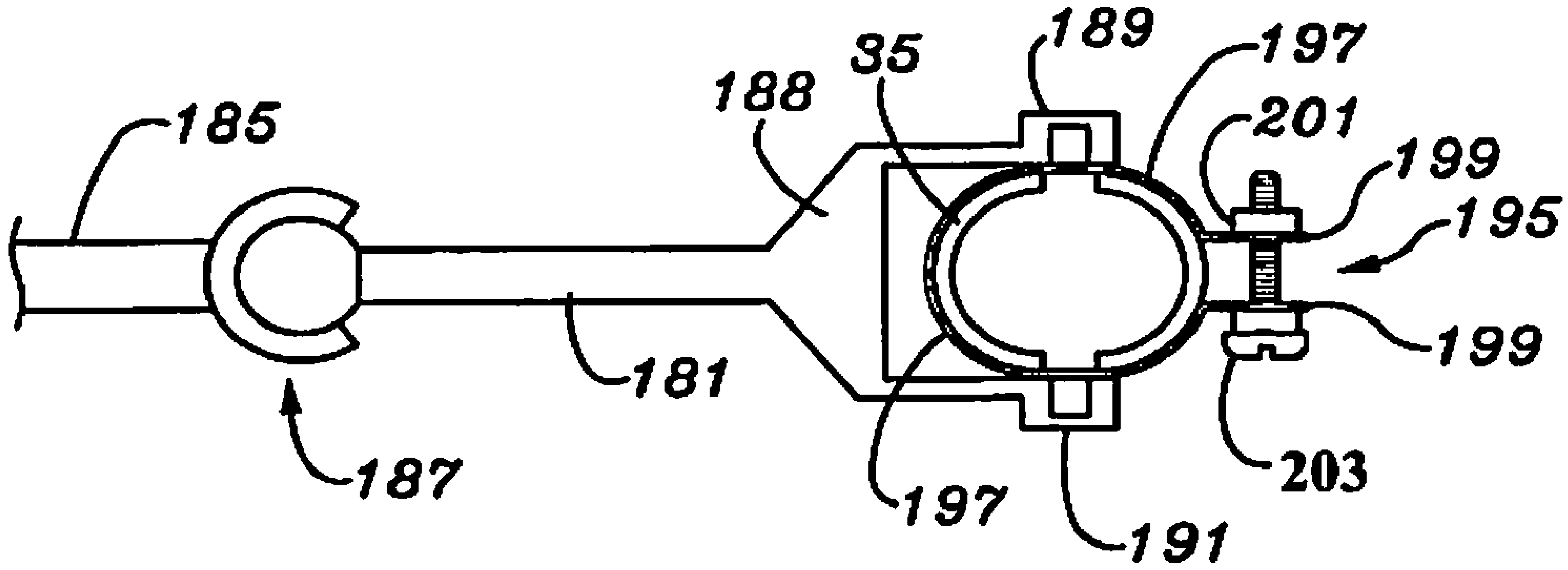
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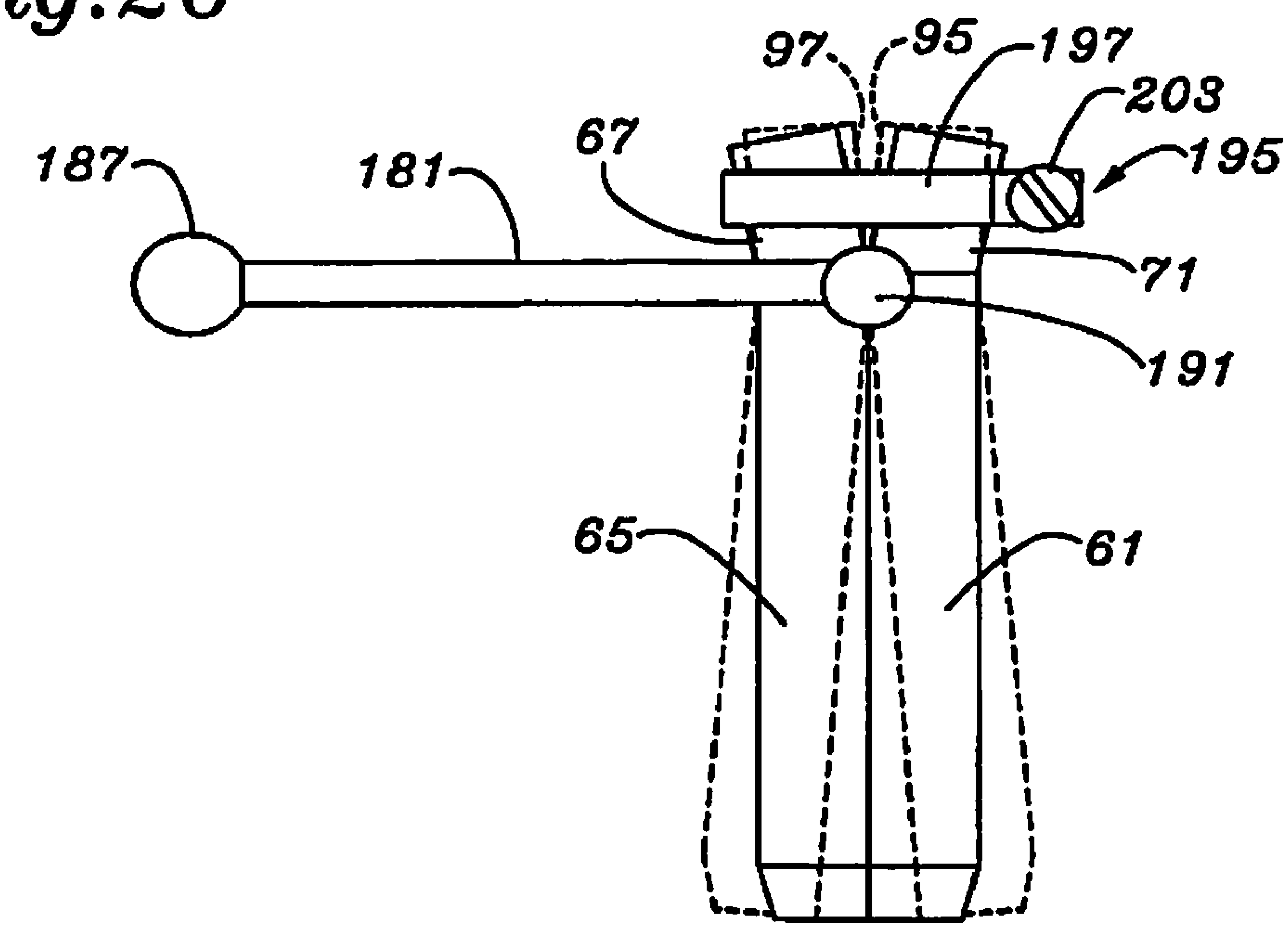
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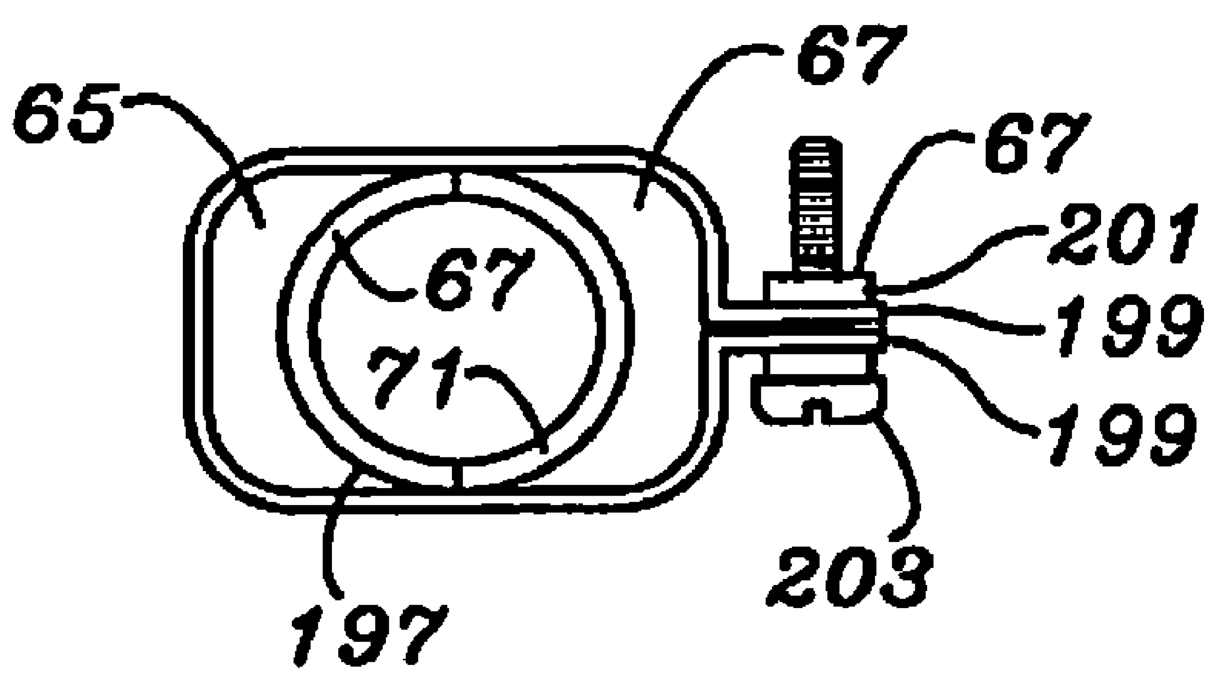
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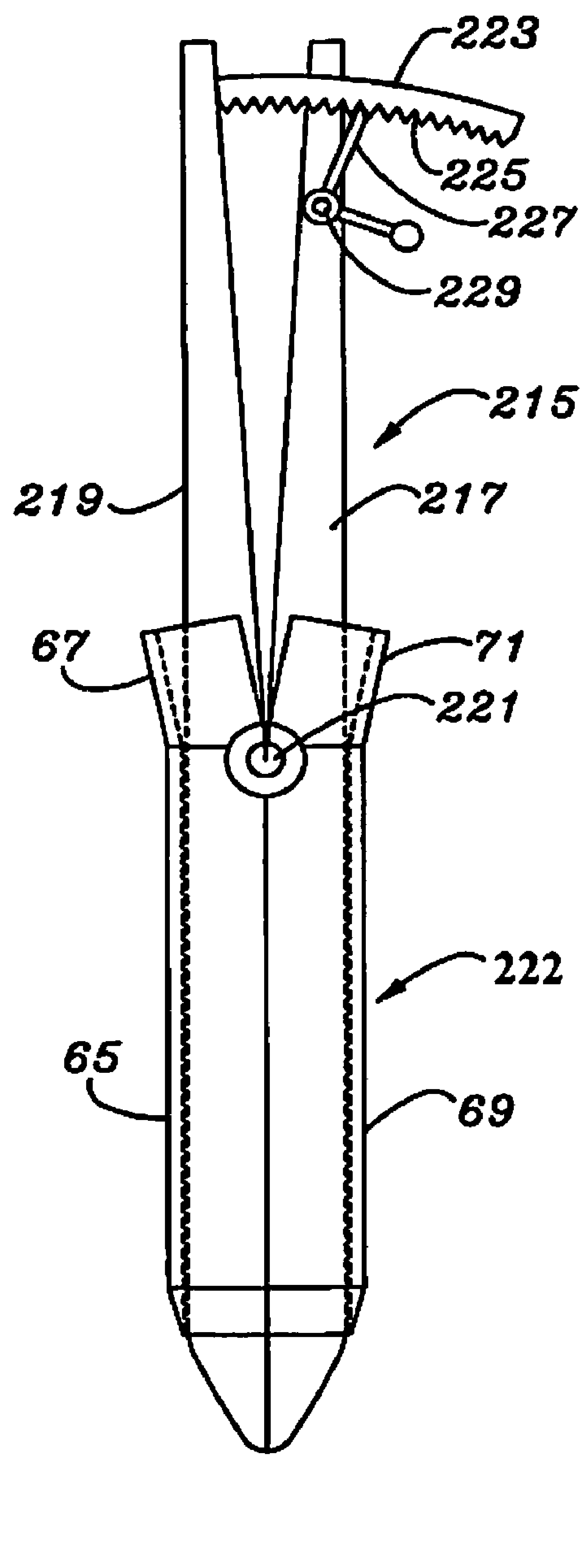
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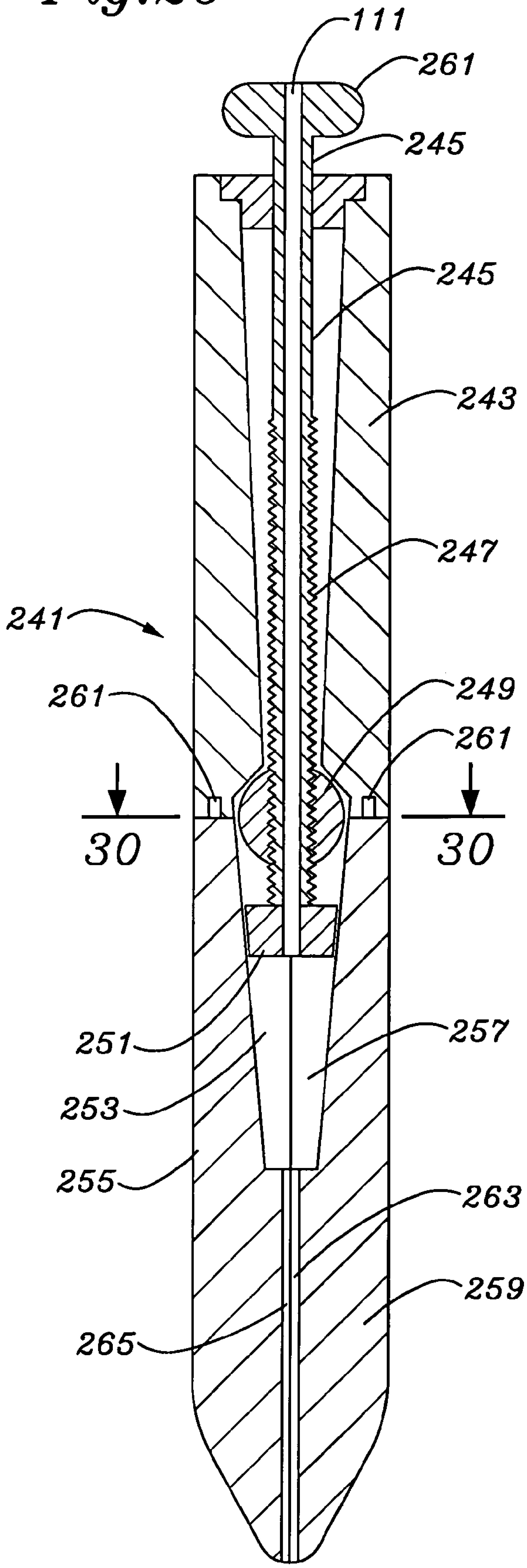

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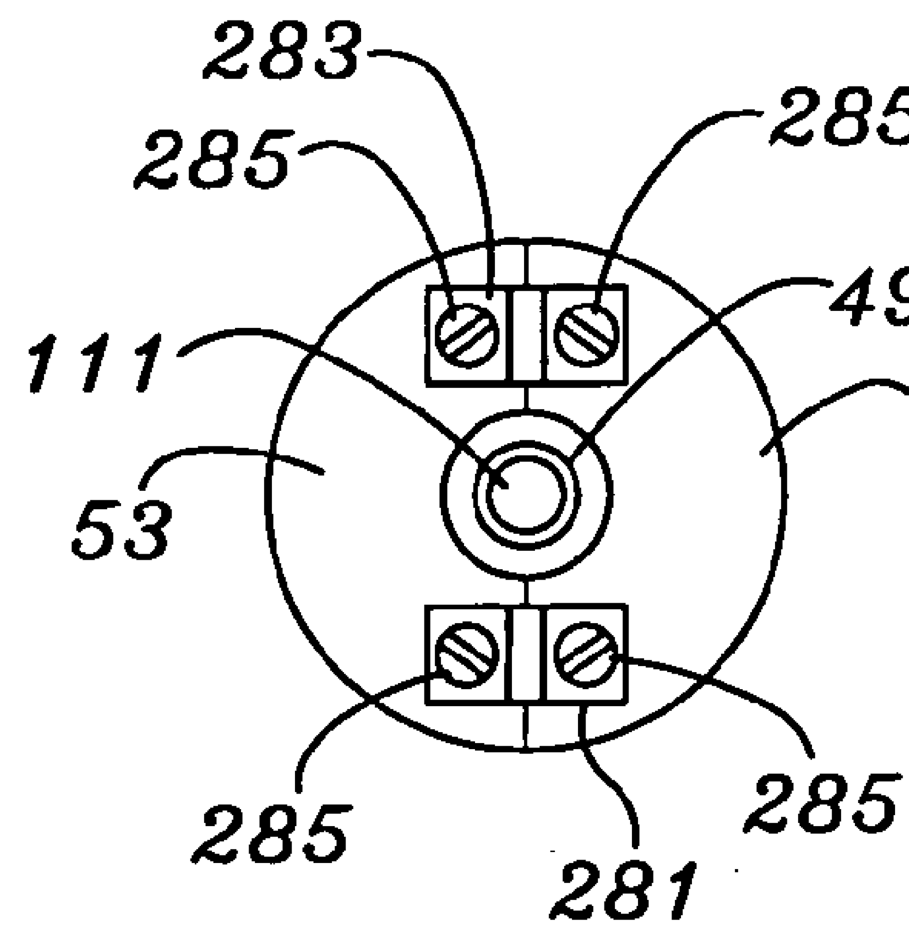

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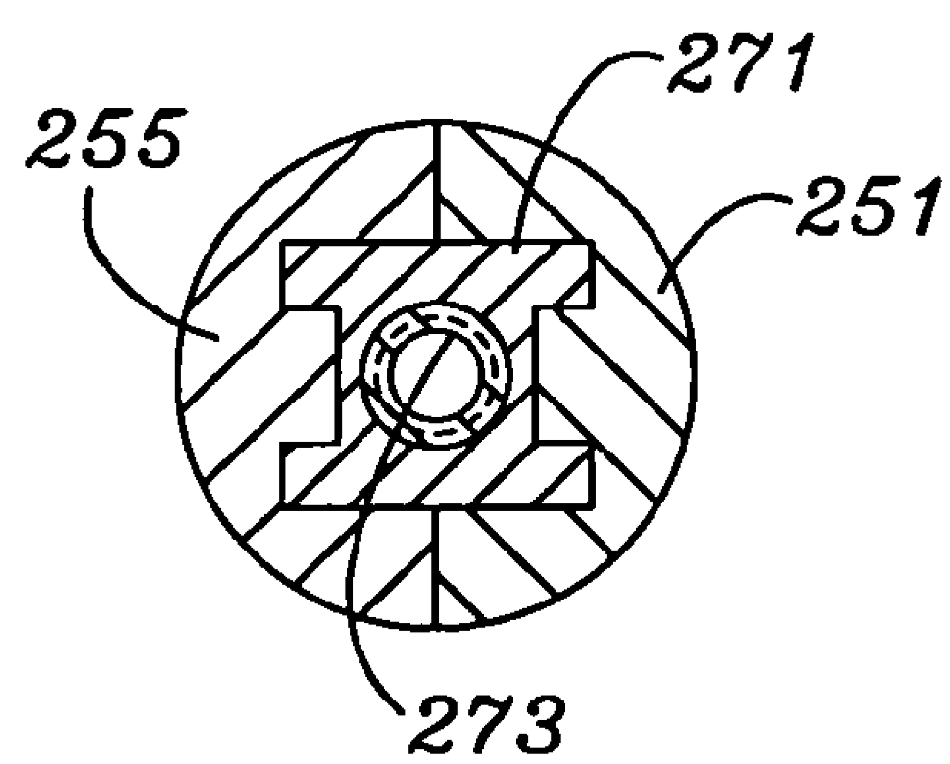

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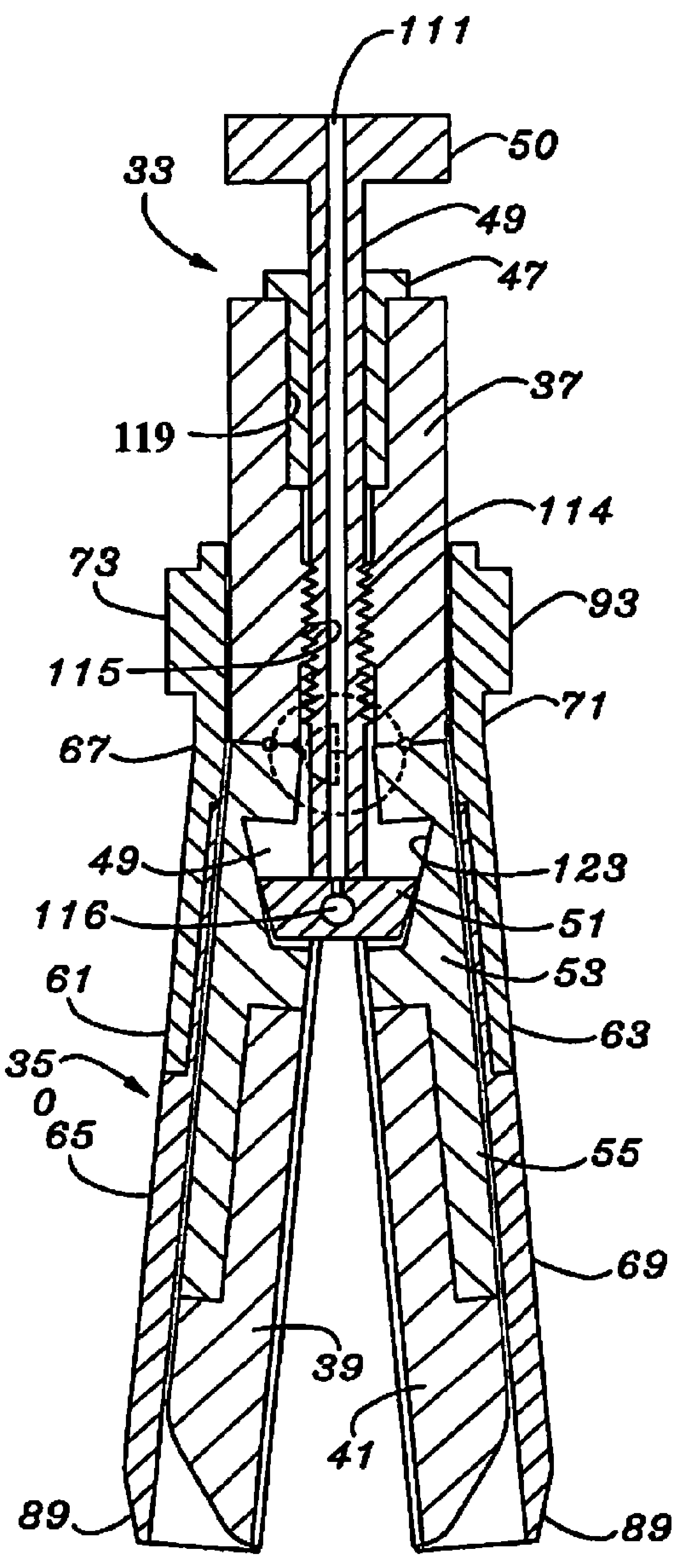
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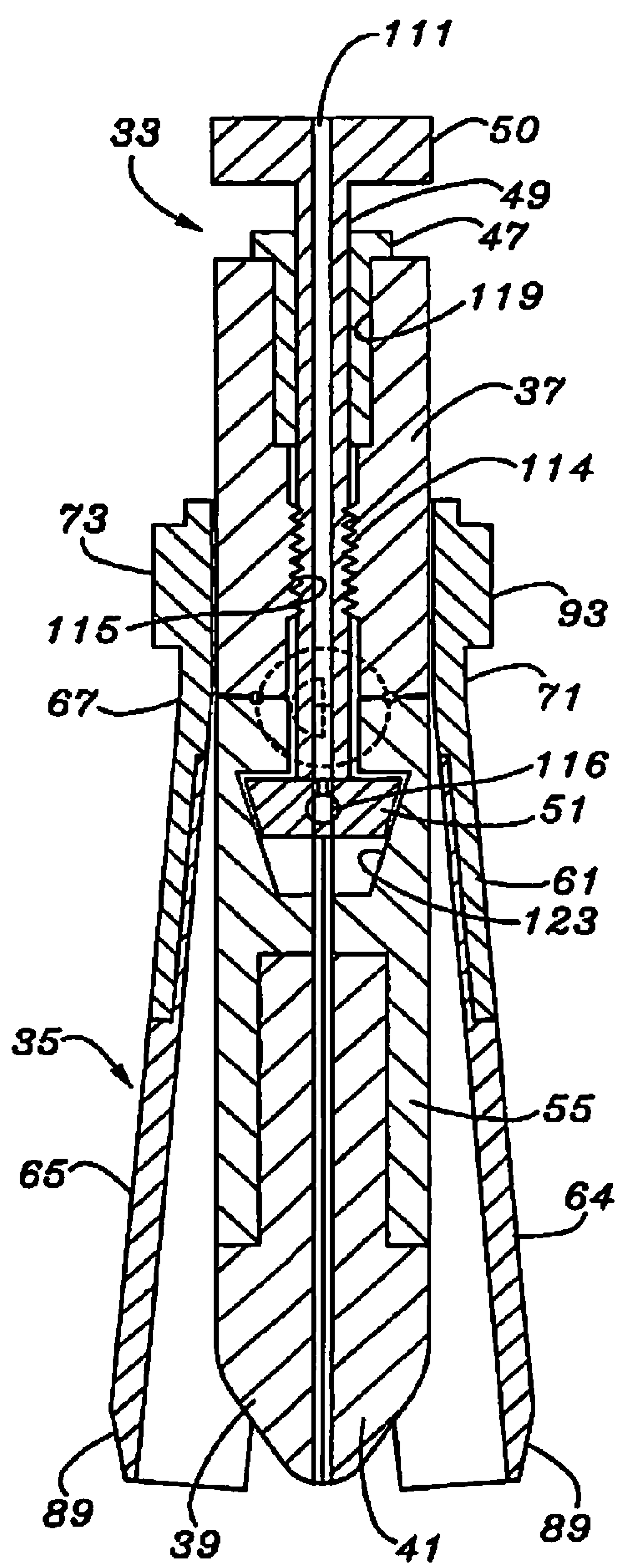
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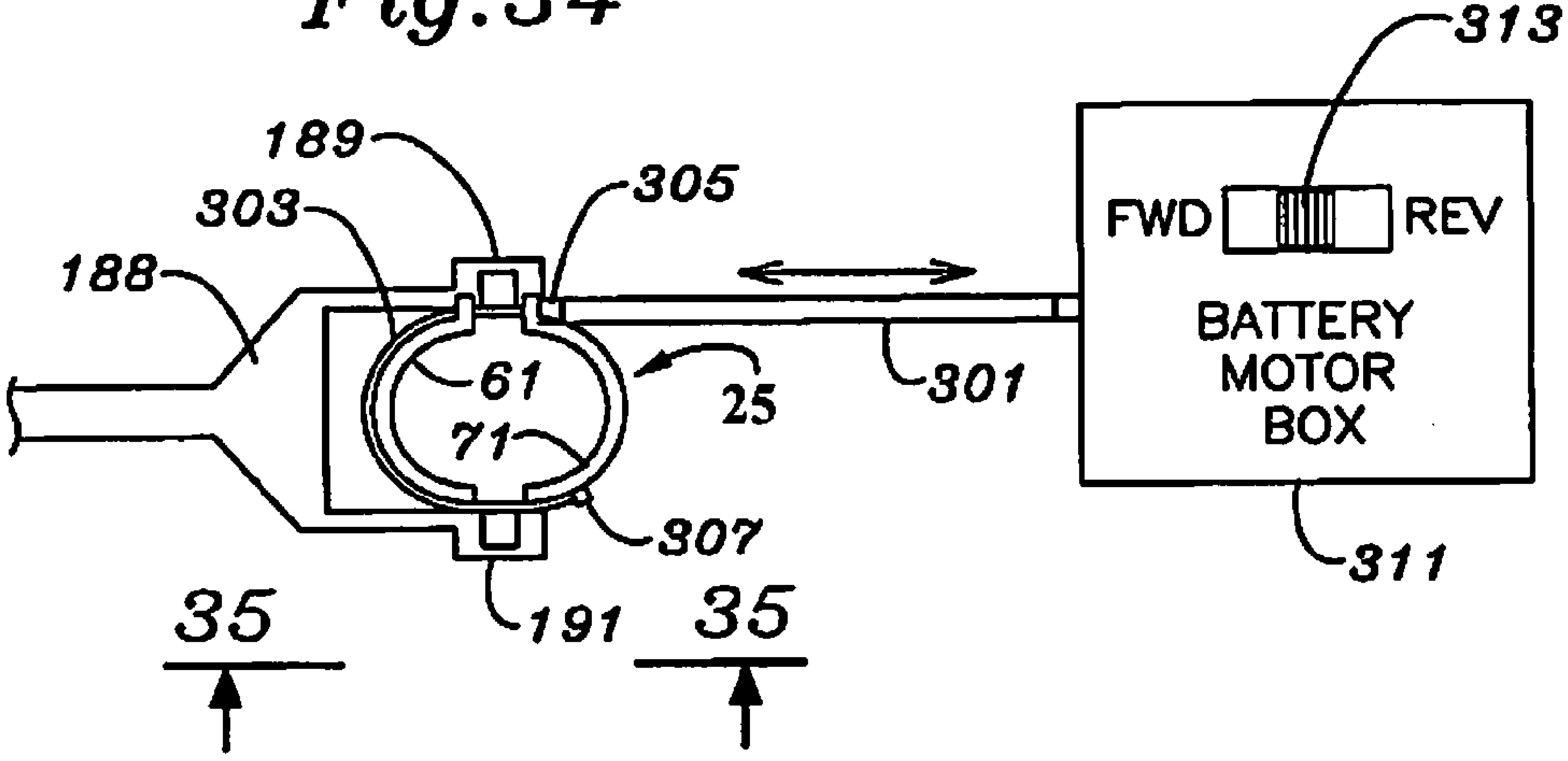

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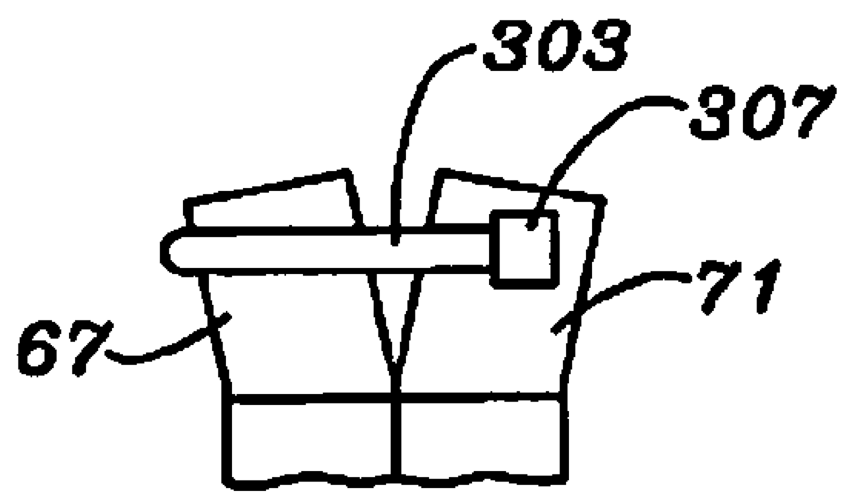

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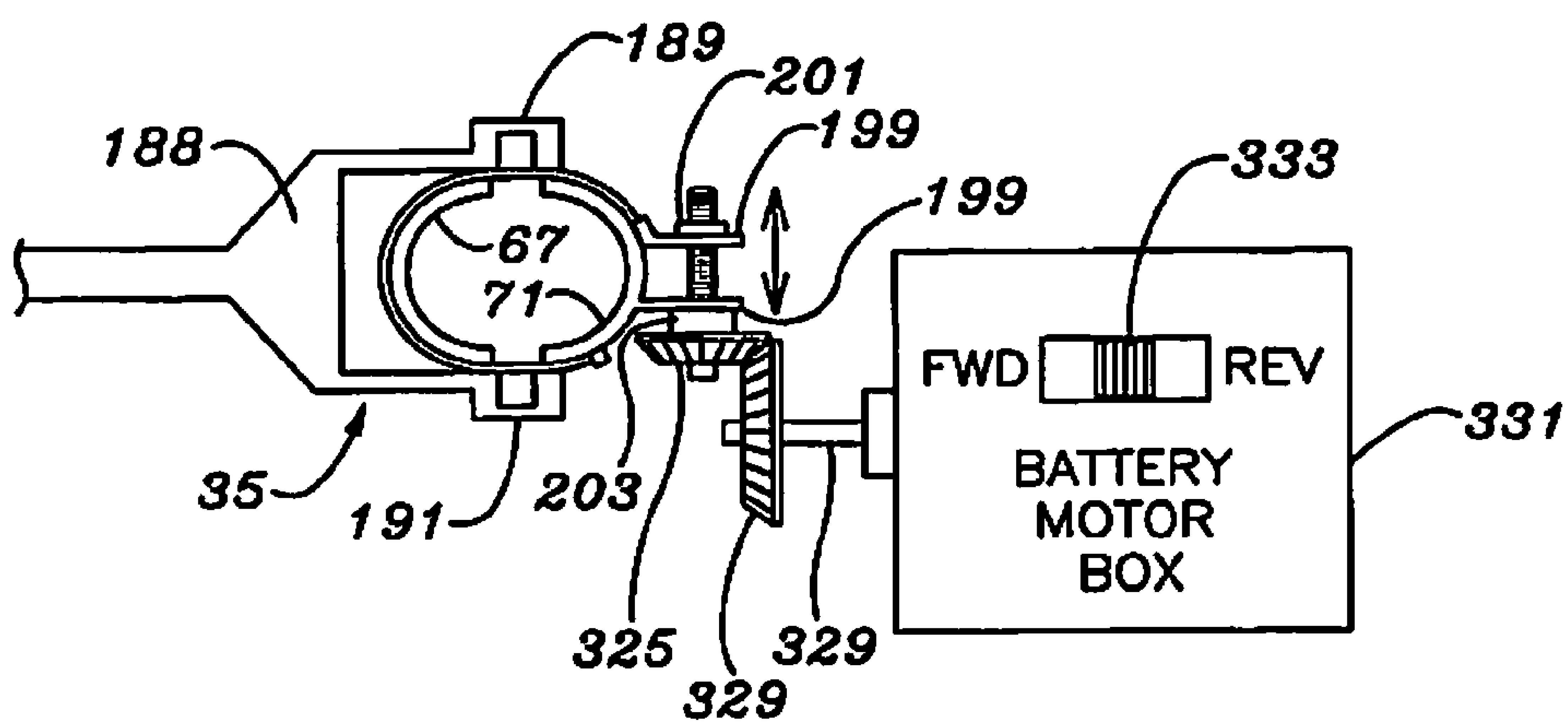

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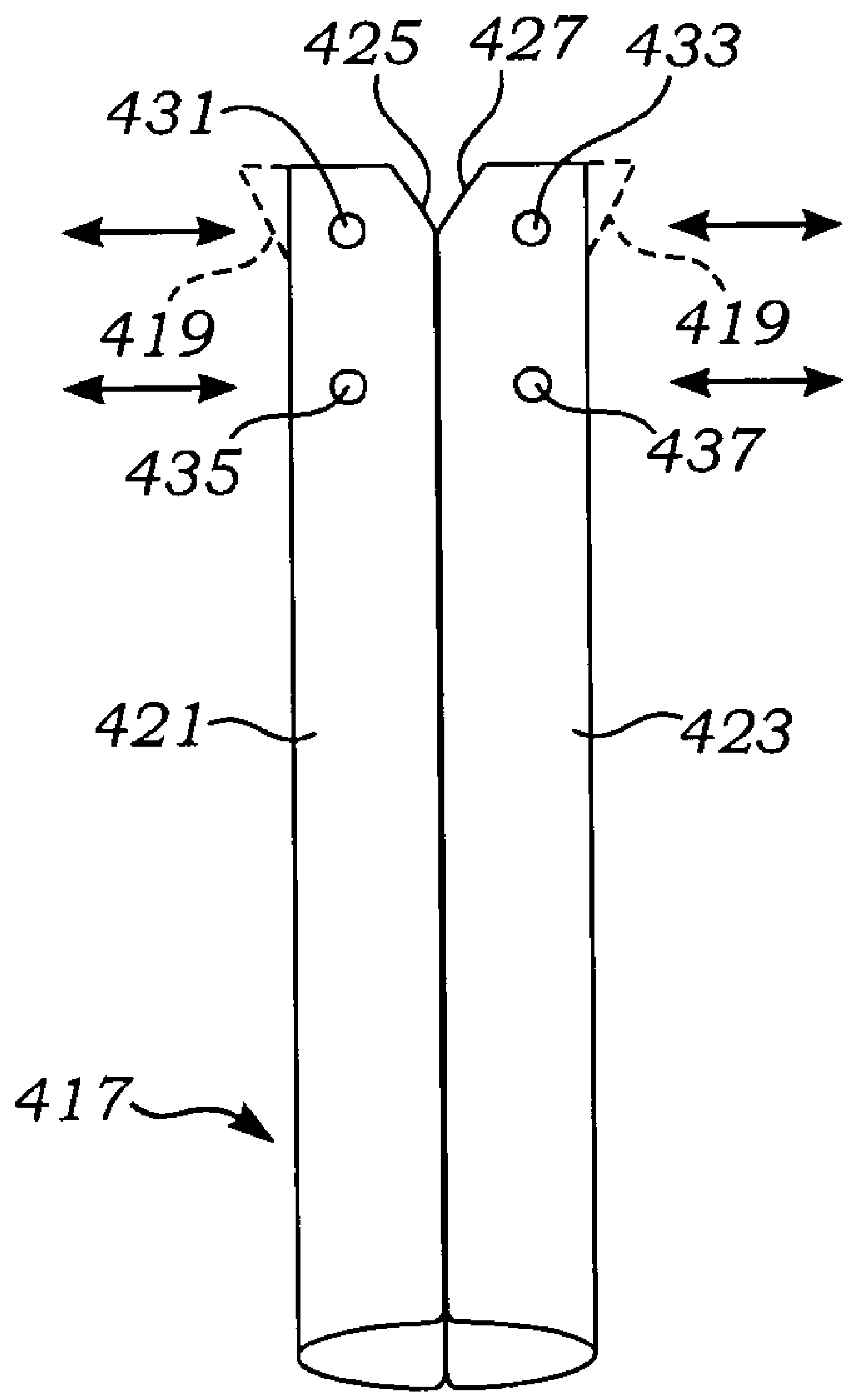

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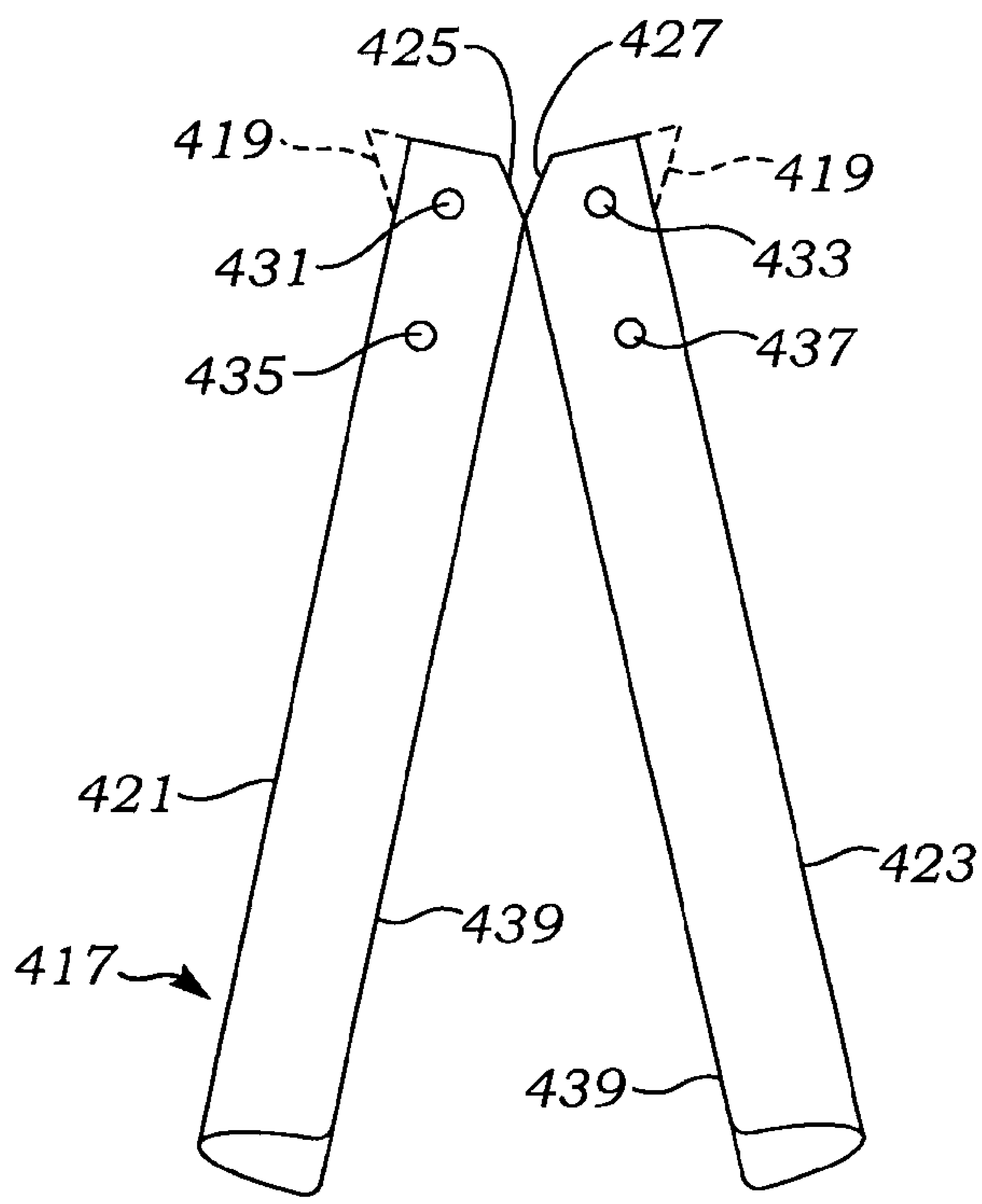

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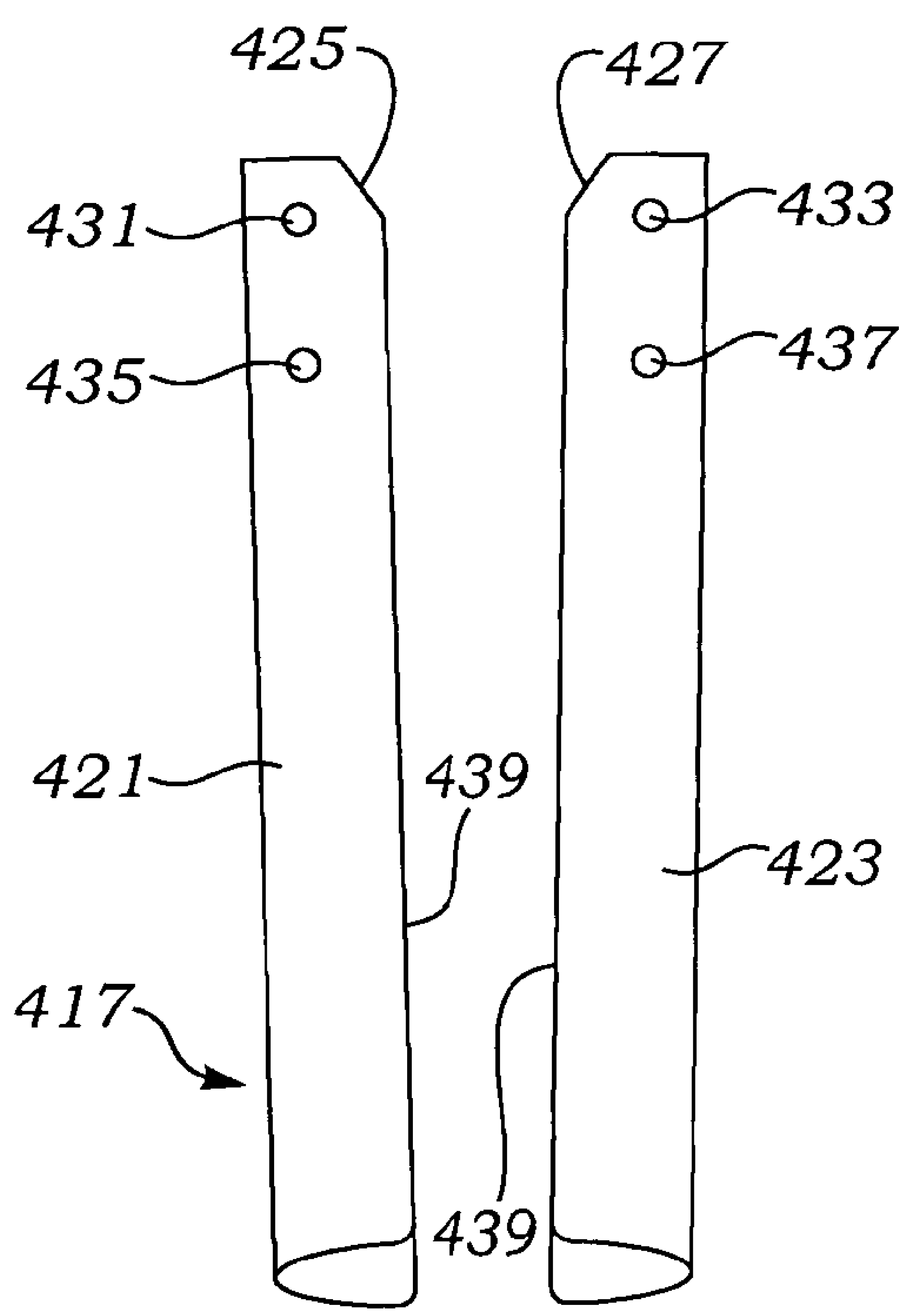

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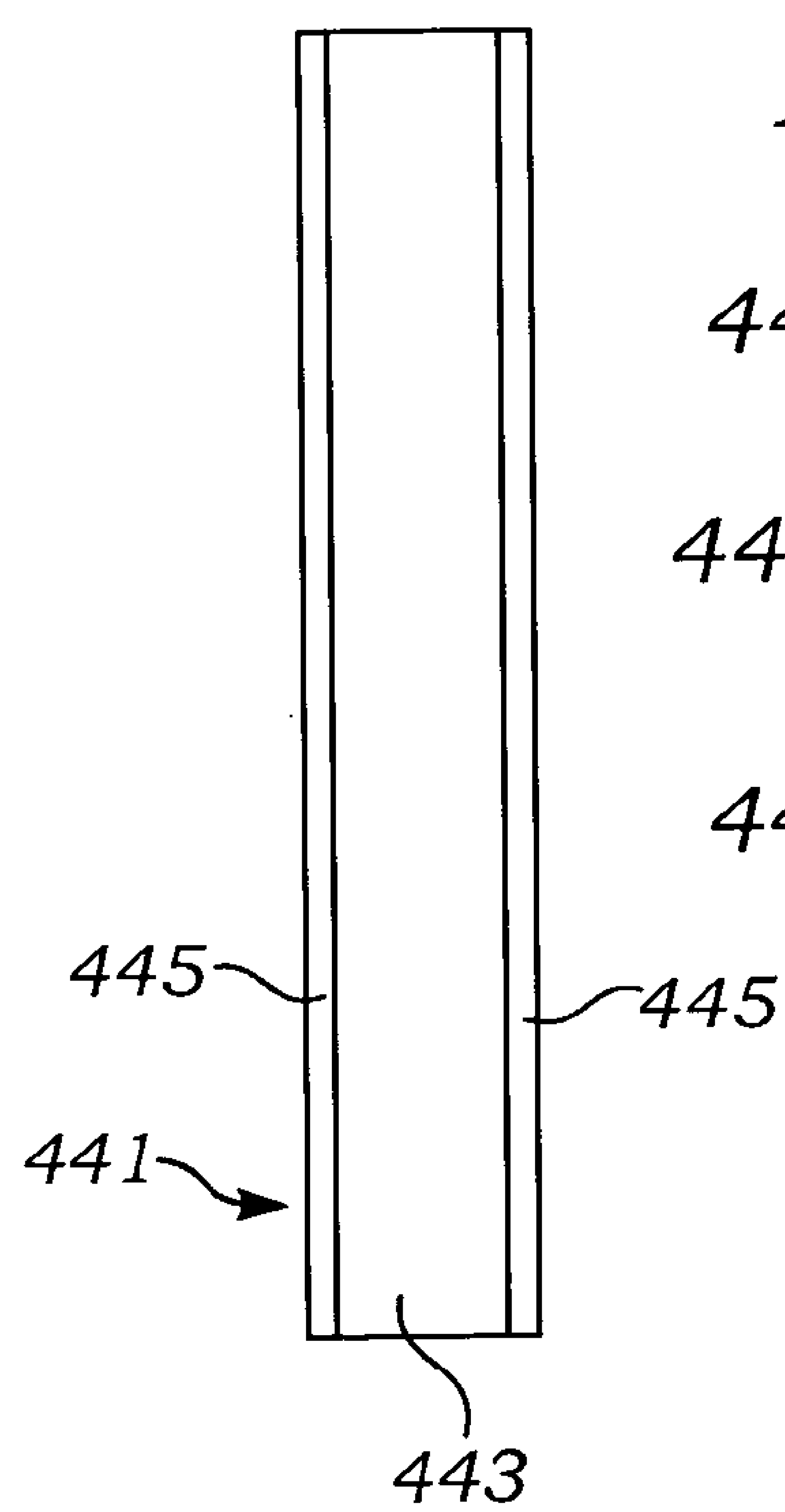


Fig. 41

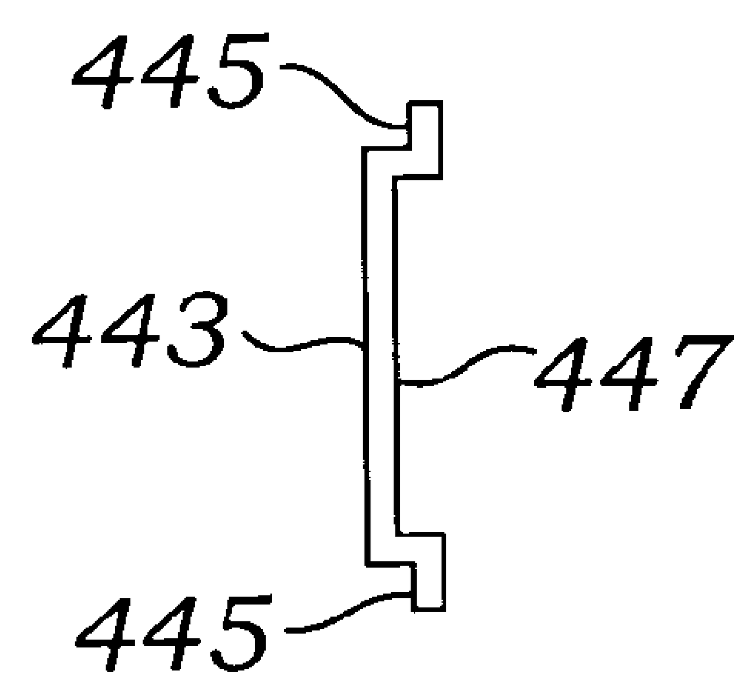


Fig. 42

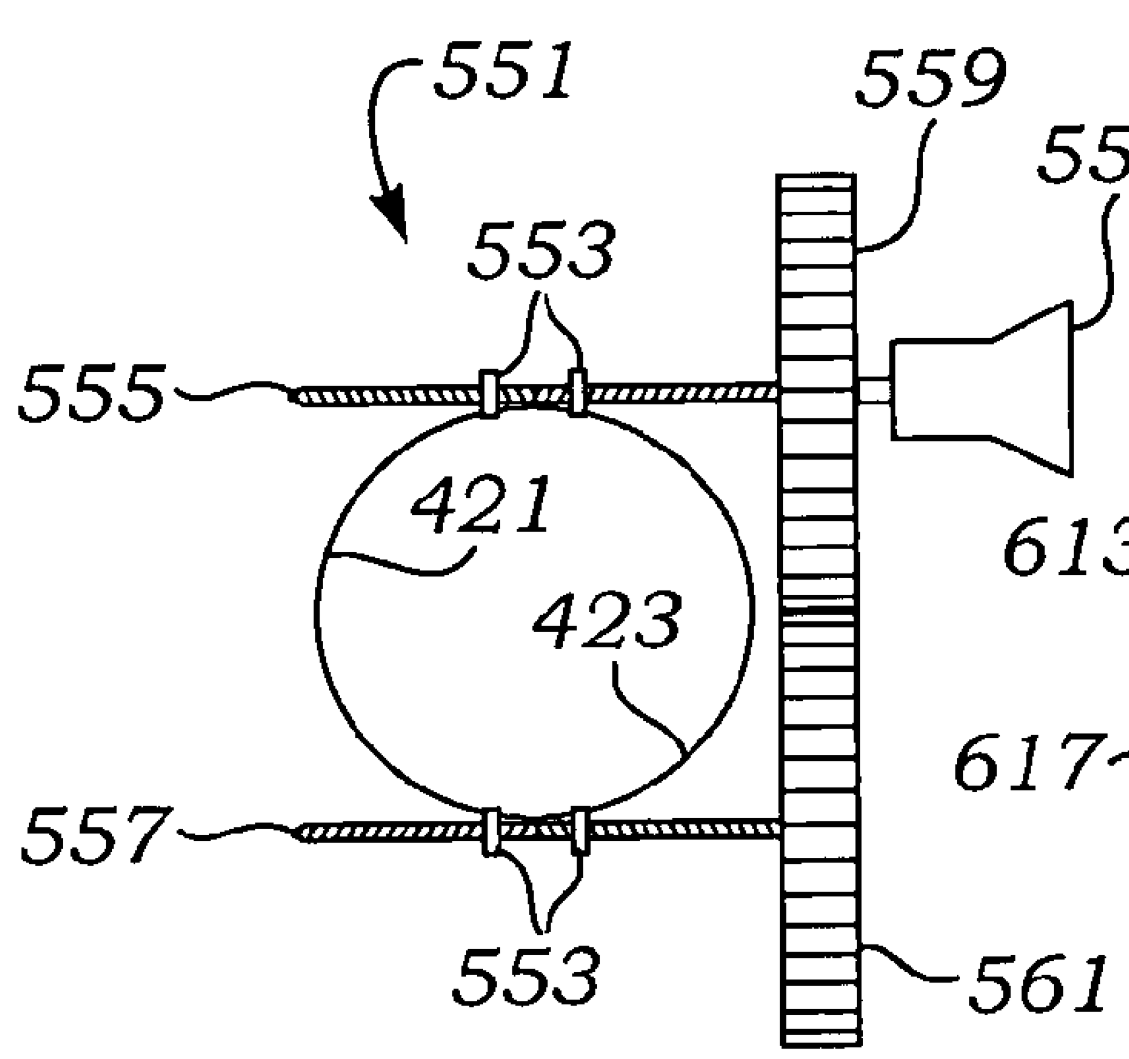


Fig. 43

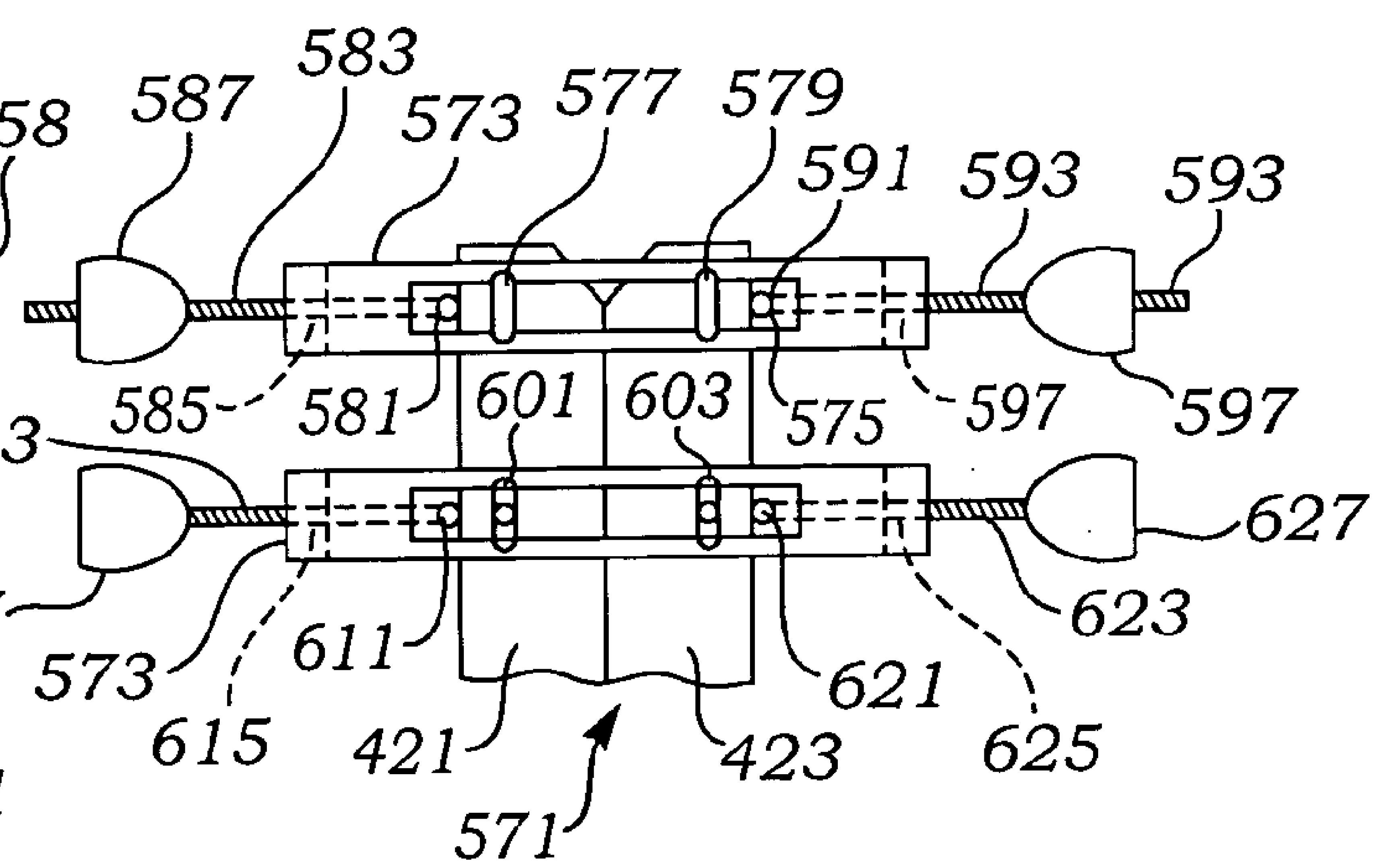


Fig. 44

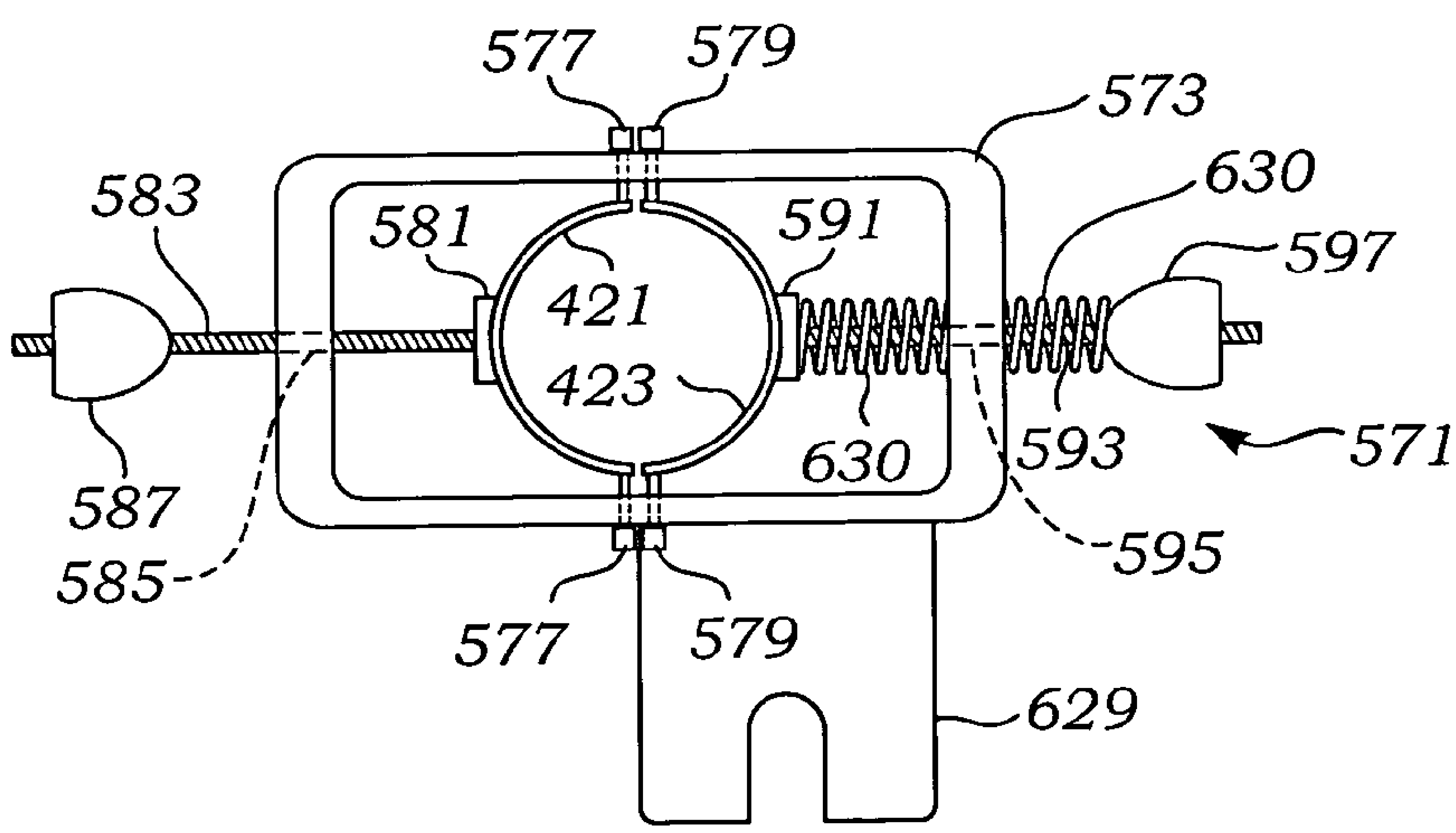
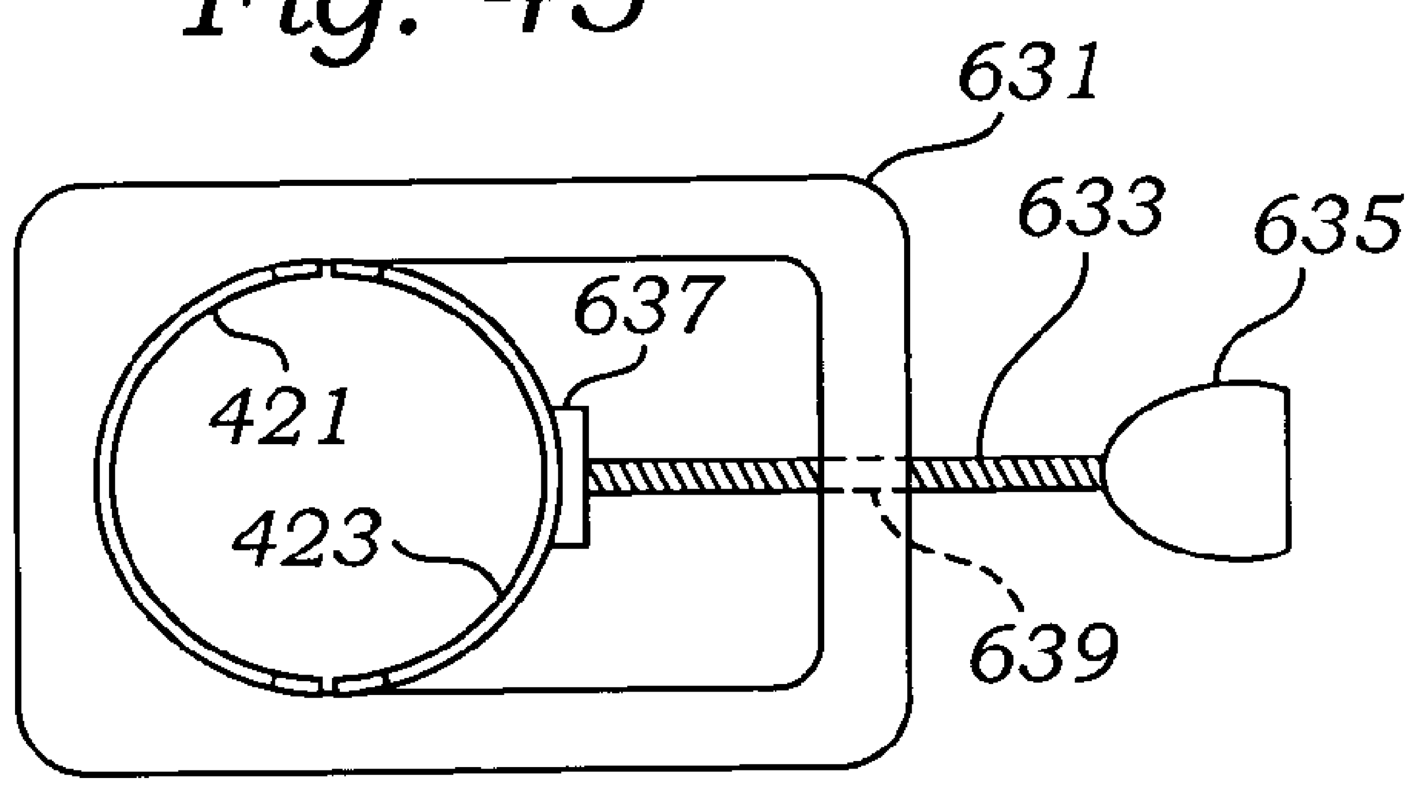


Fig. 45



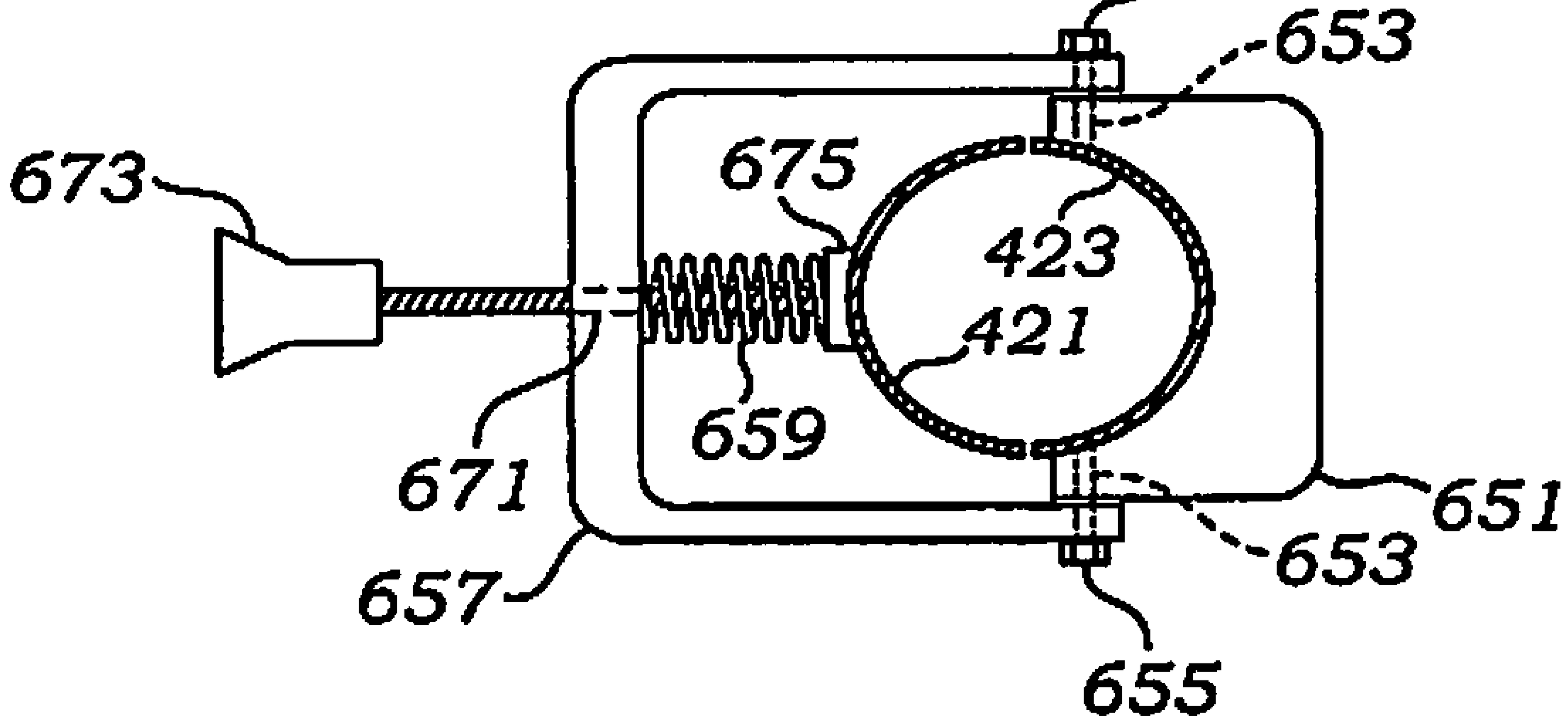


Fig. 46

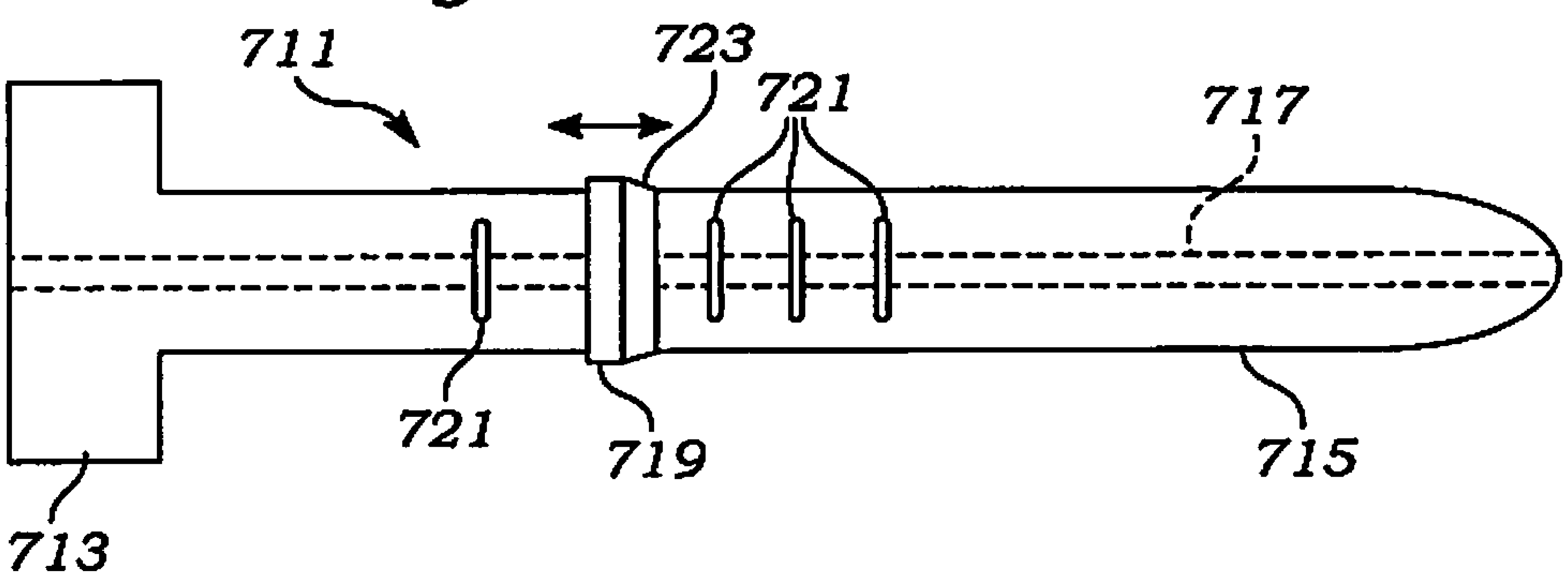


Fig. 49

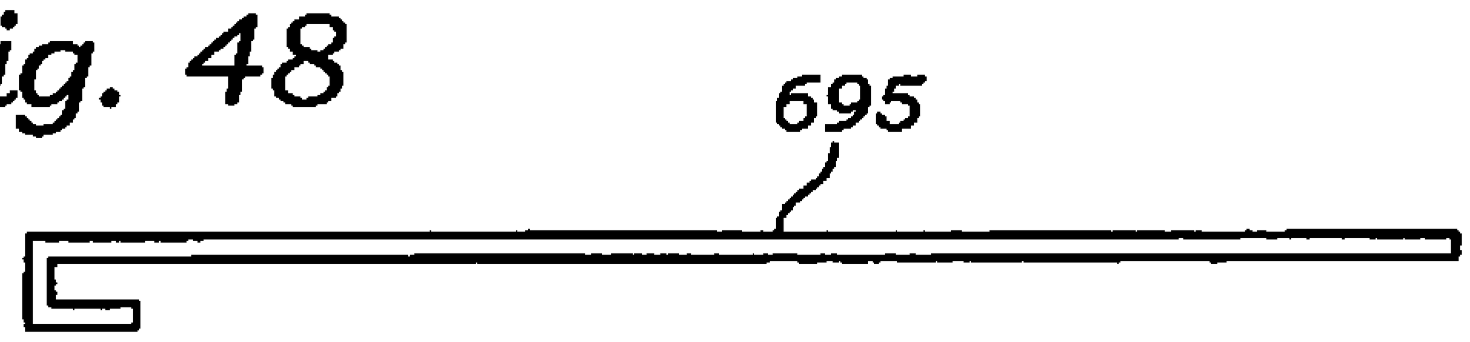


Fig. 48

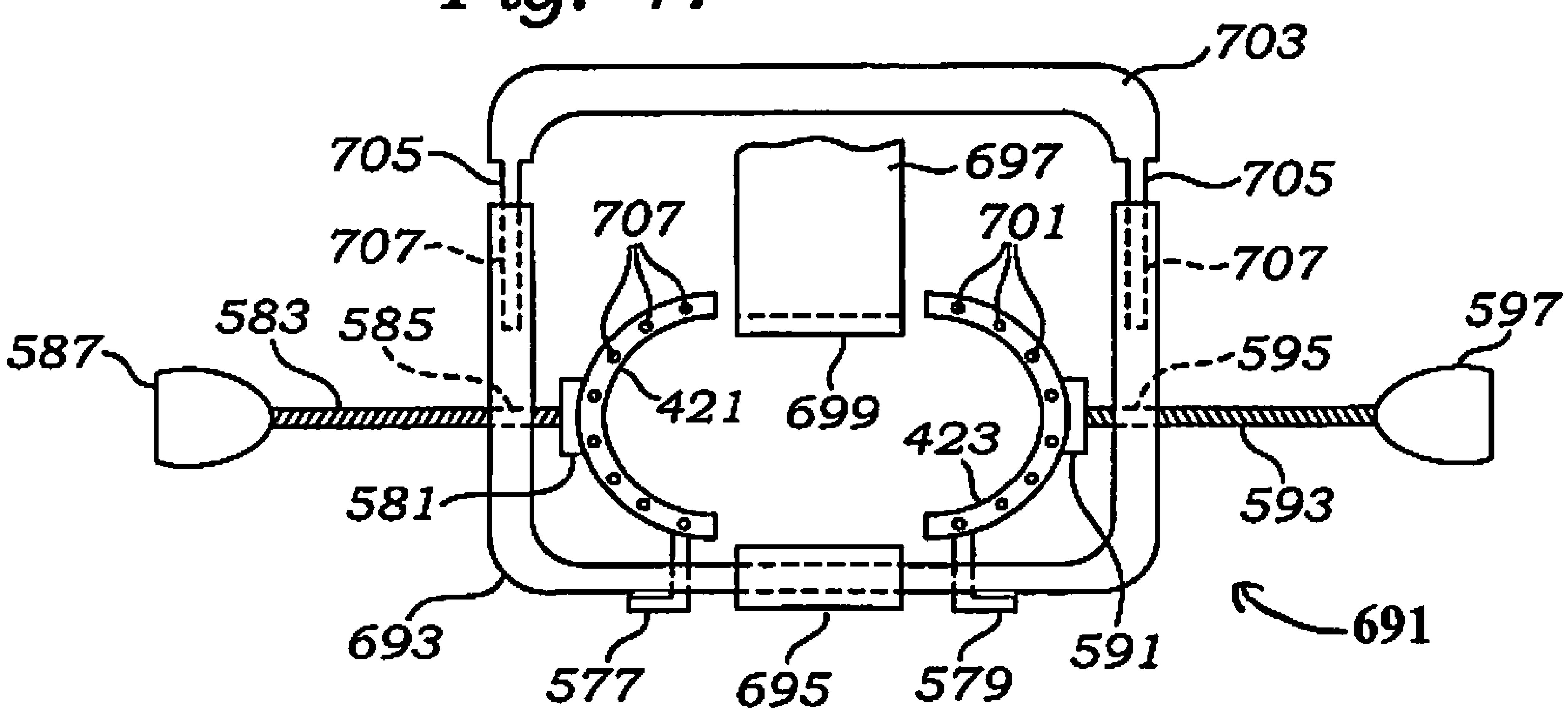


Fig. 47

Fig.50

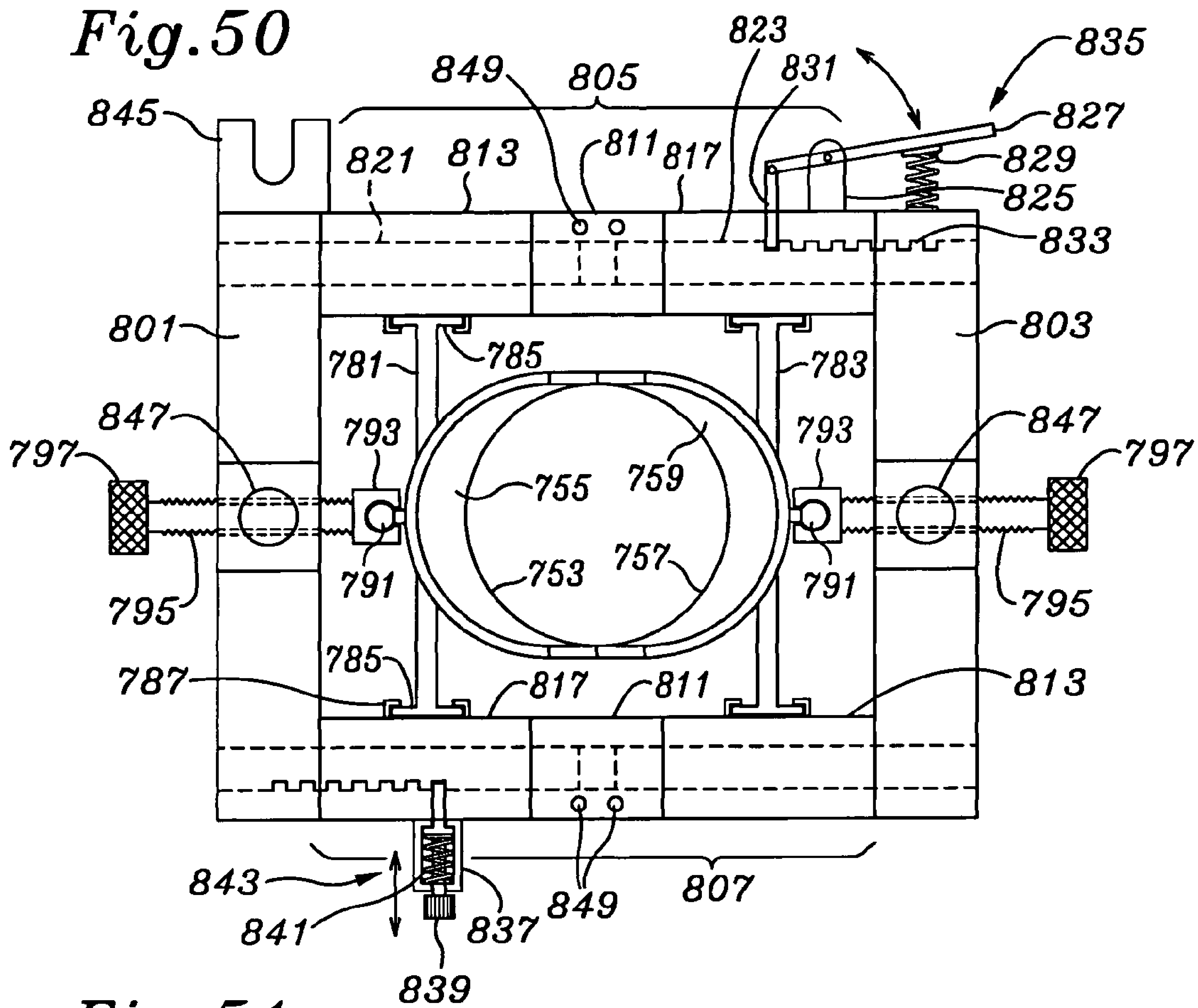

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Fig.51

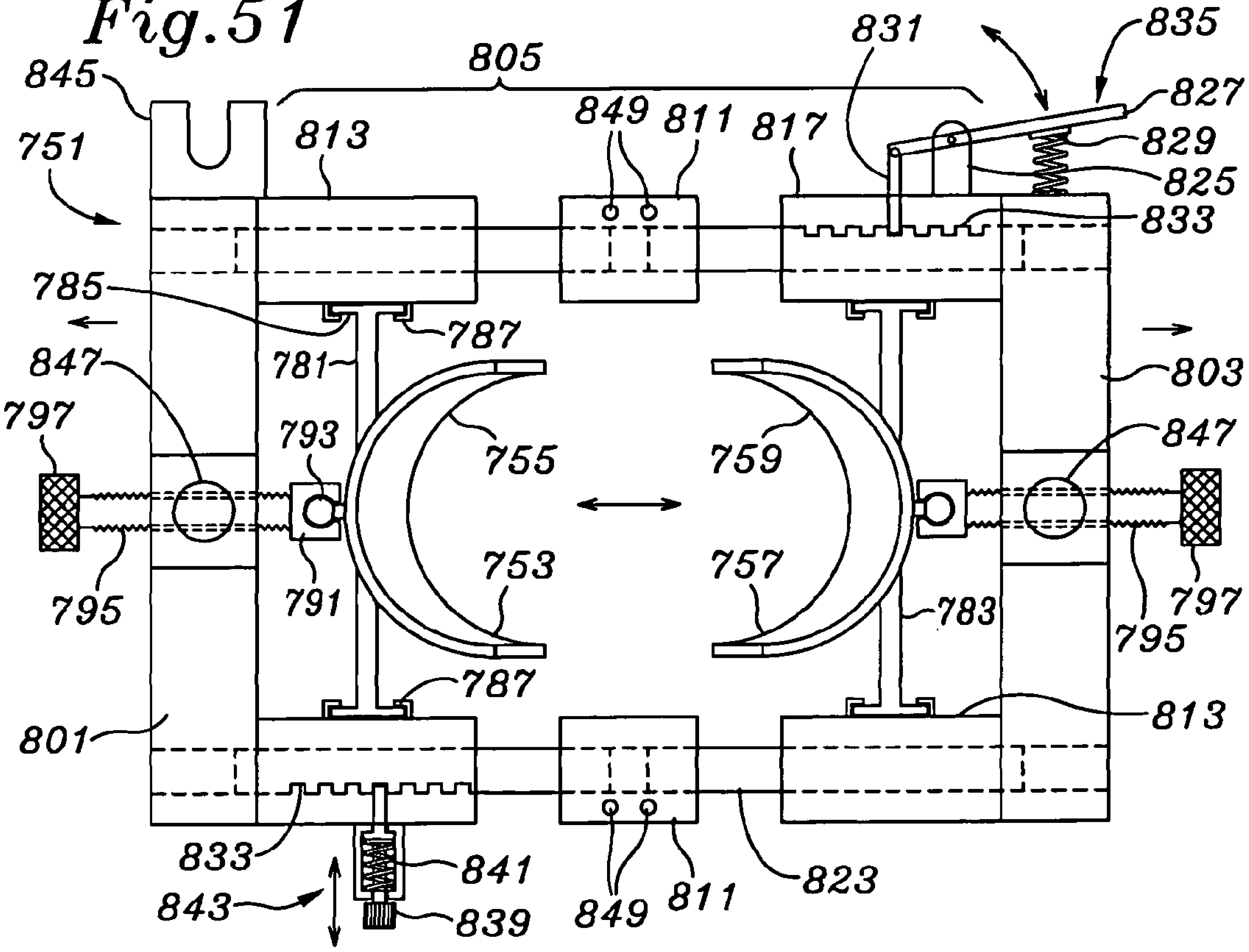
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Fig.52

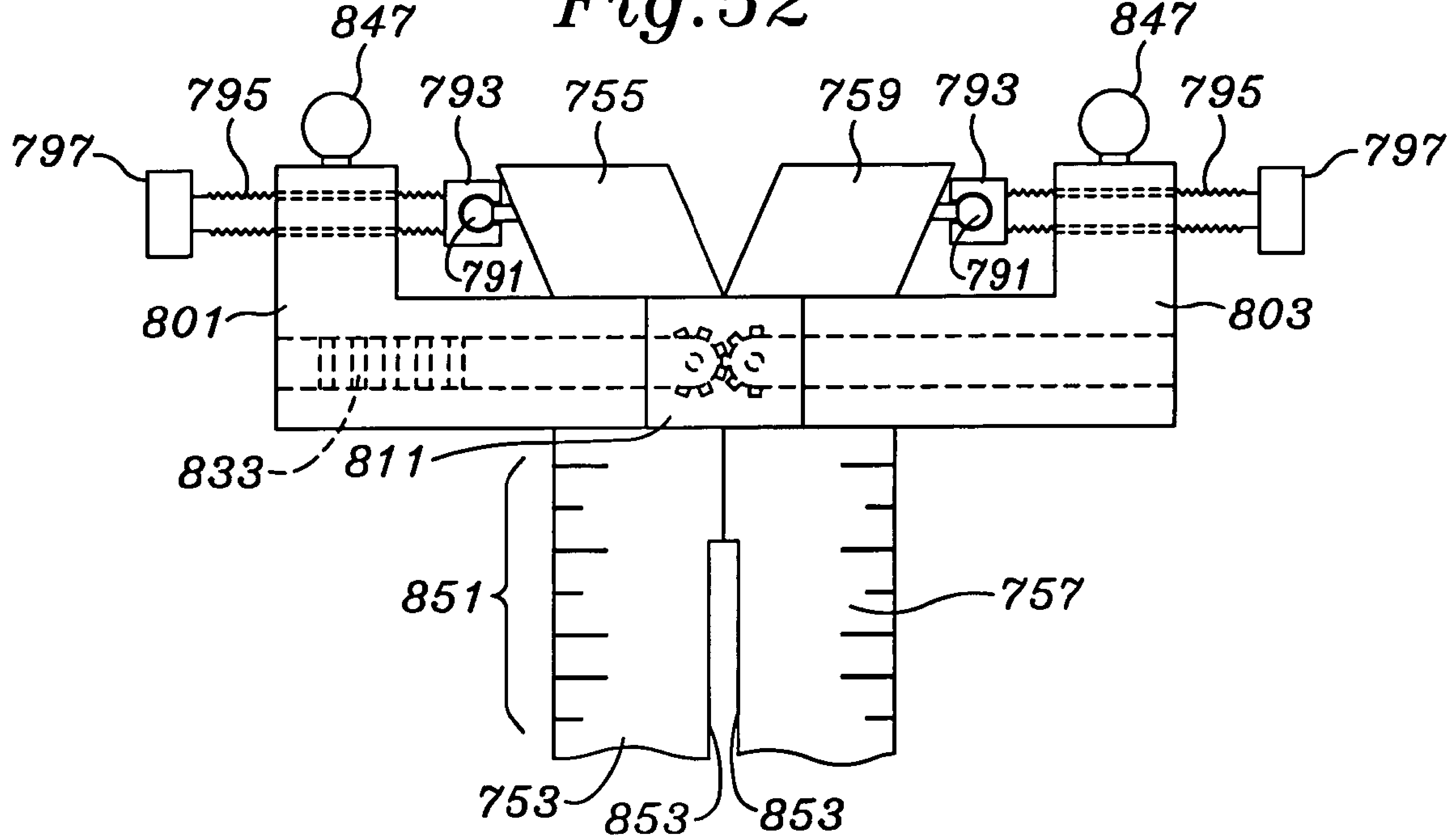

Fig.53

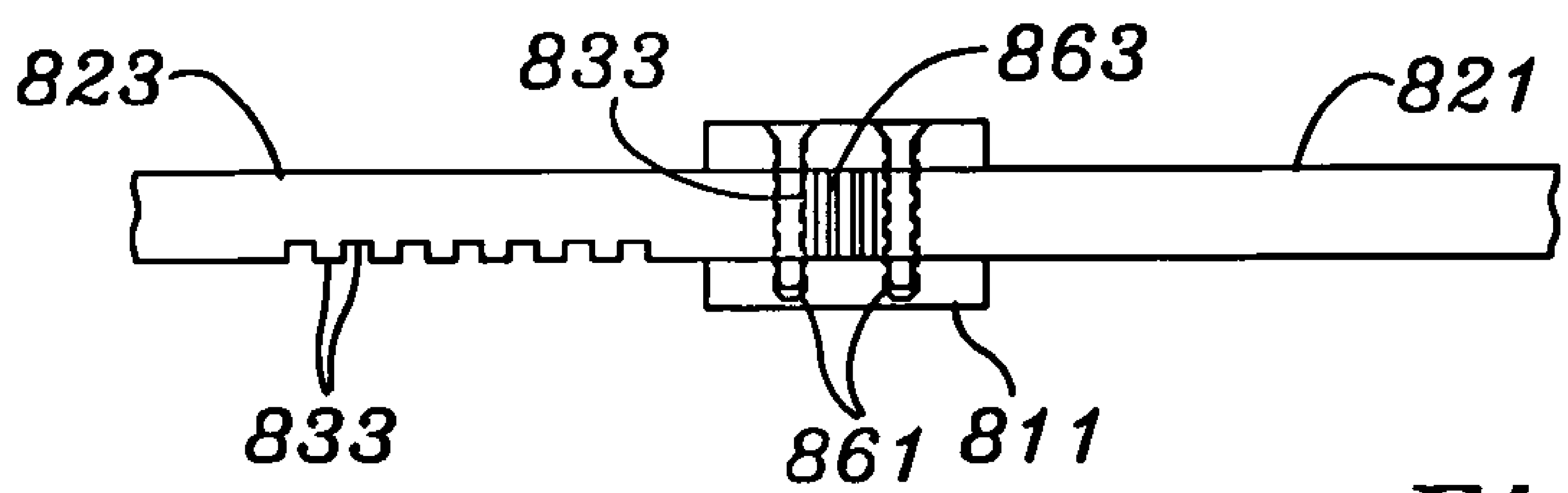

Fig.55

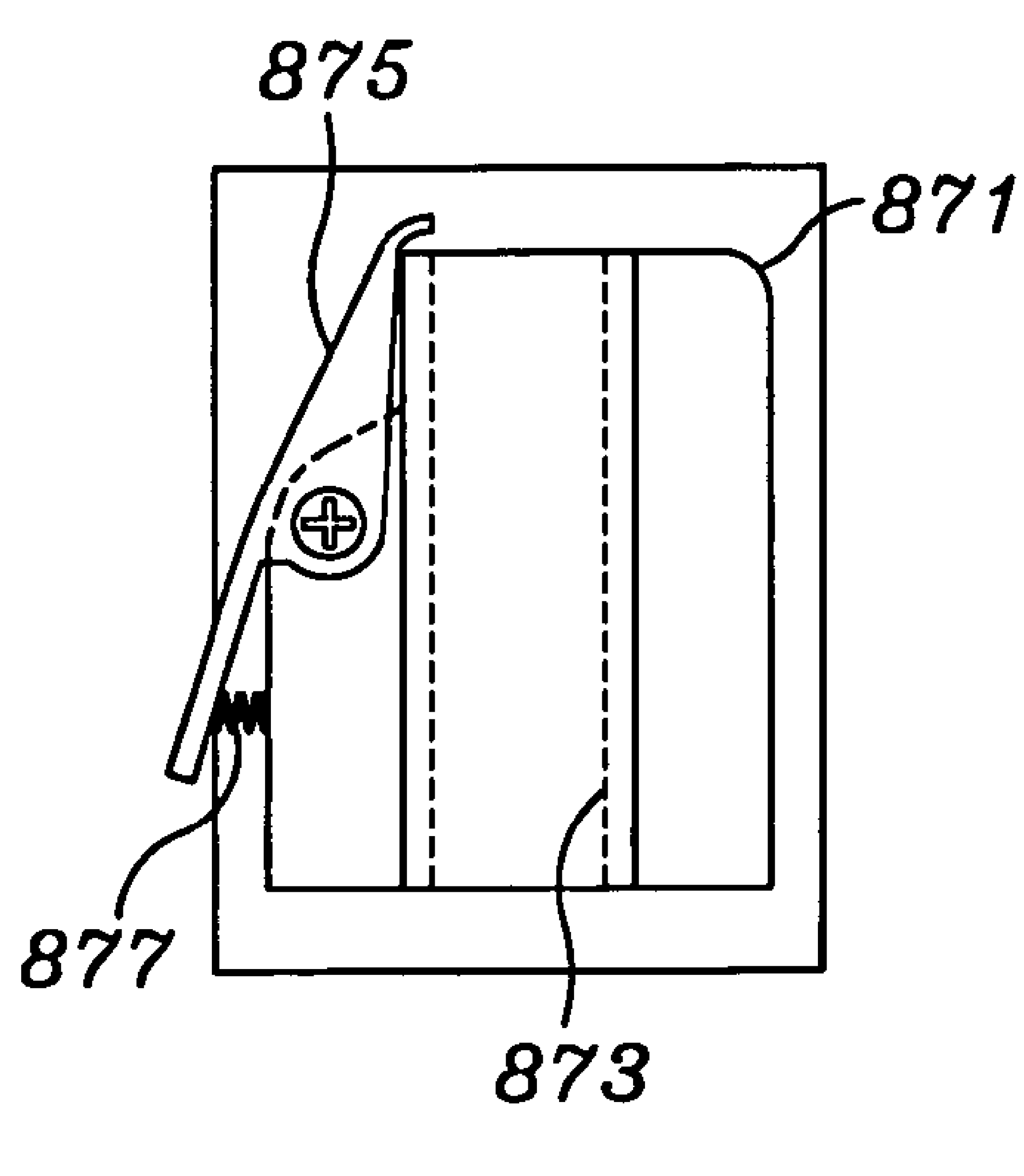

Fig.54

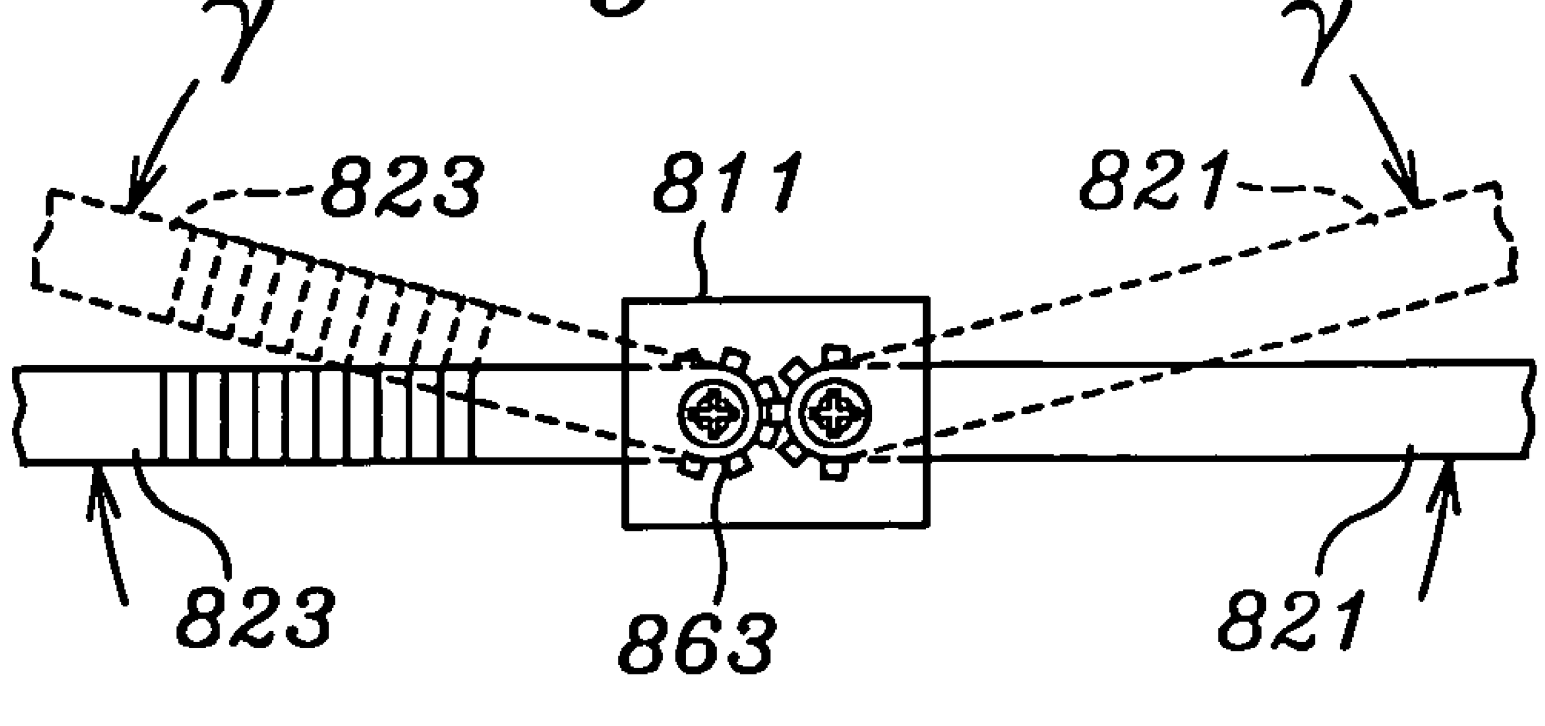

Fig. 56

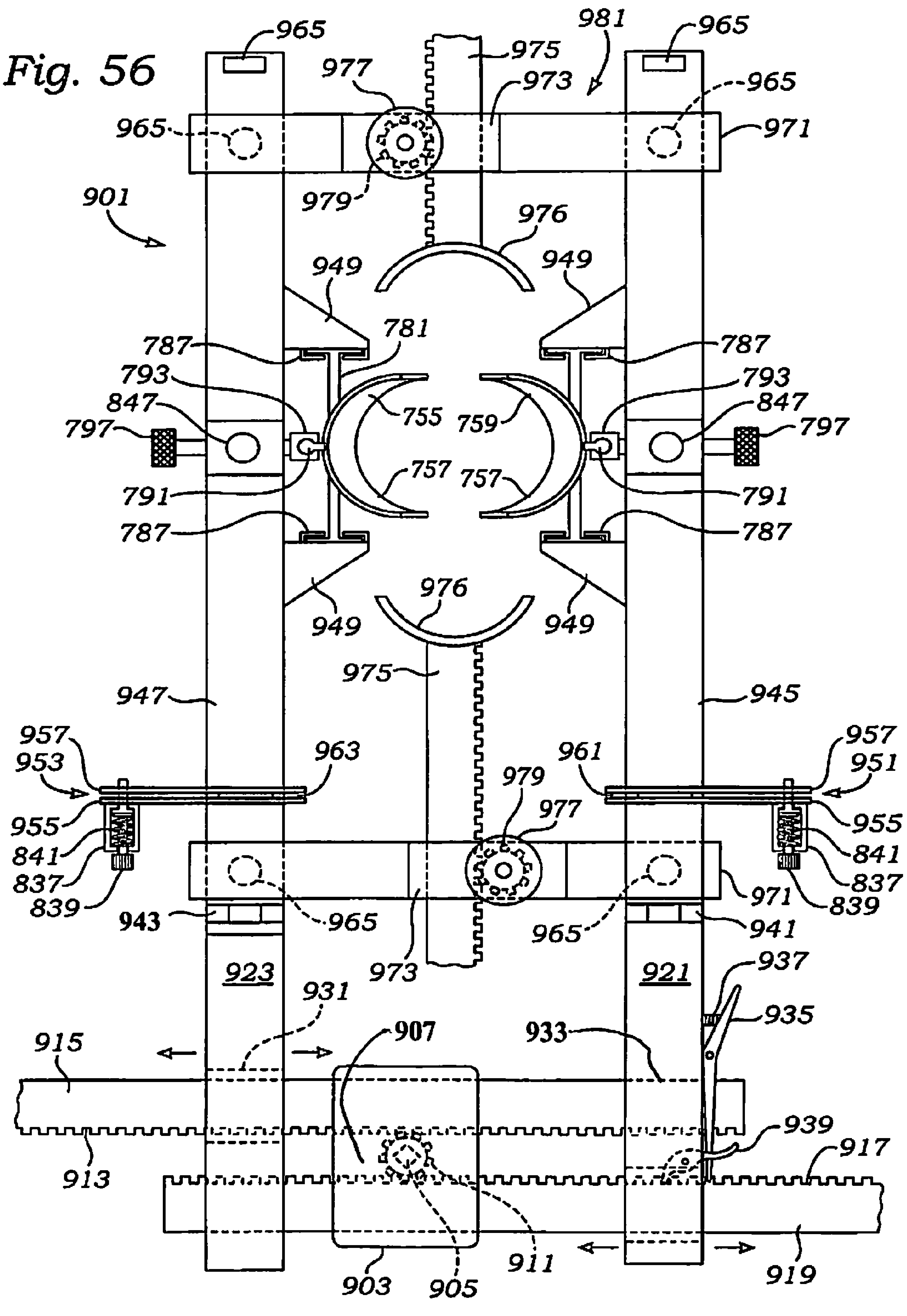
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Fig. 57

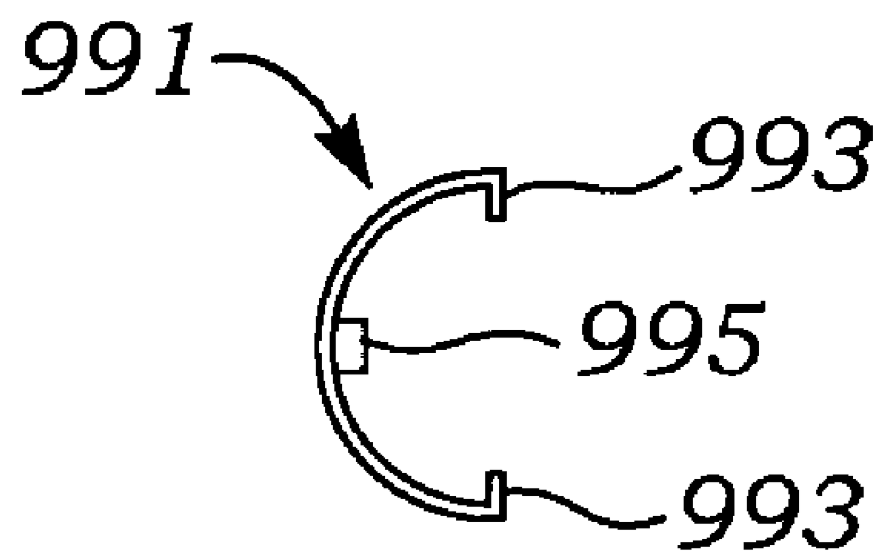


Fig. 58

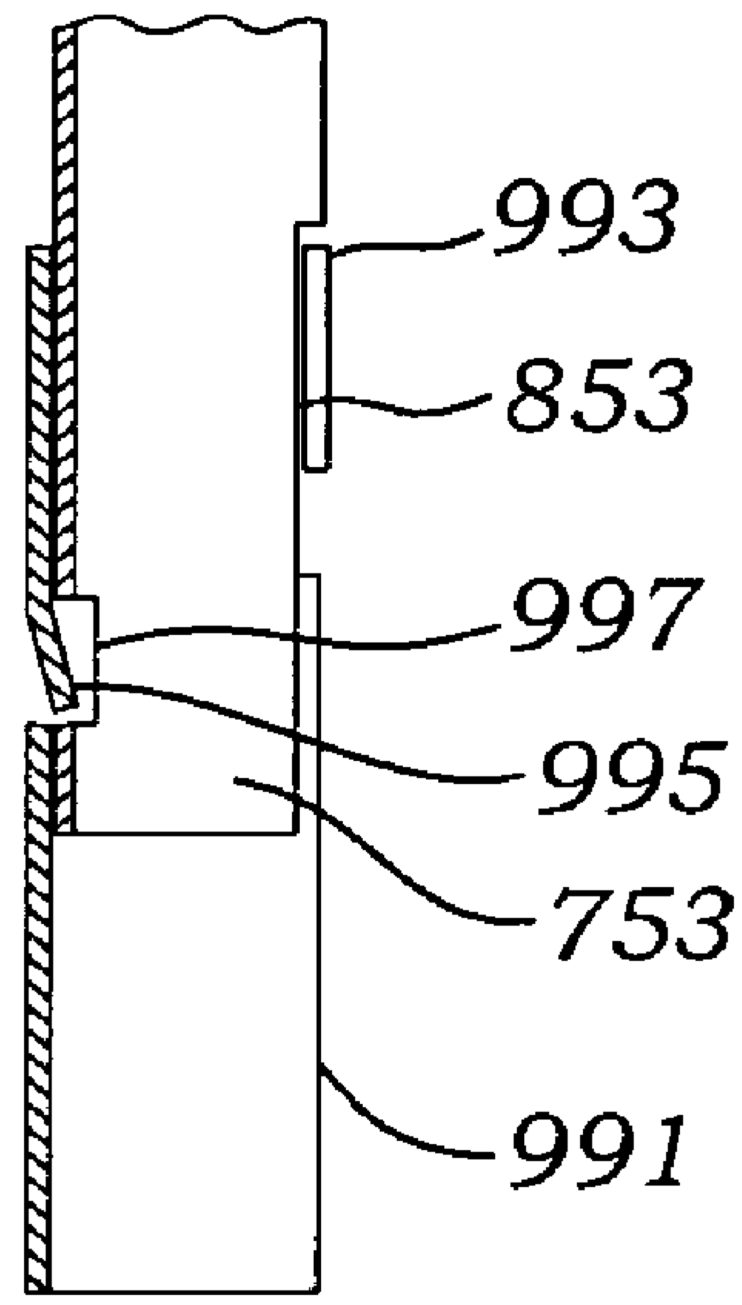


Fig. 59

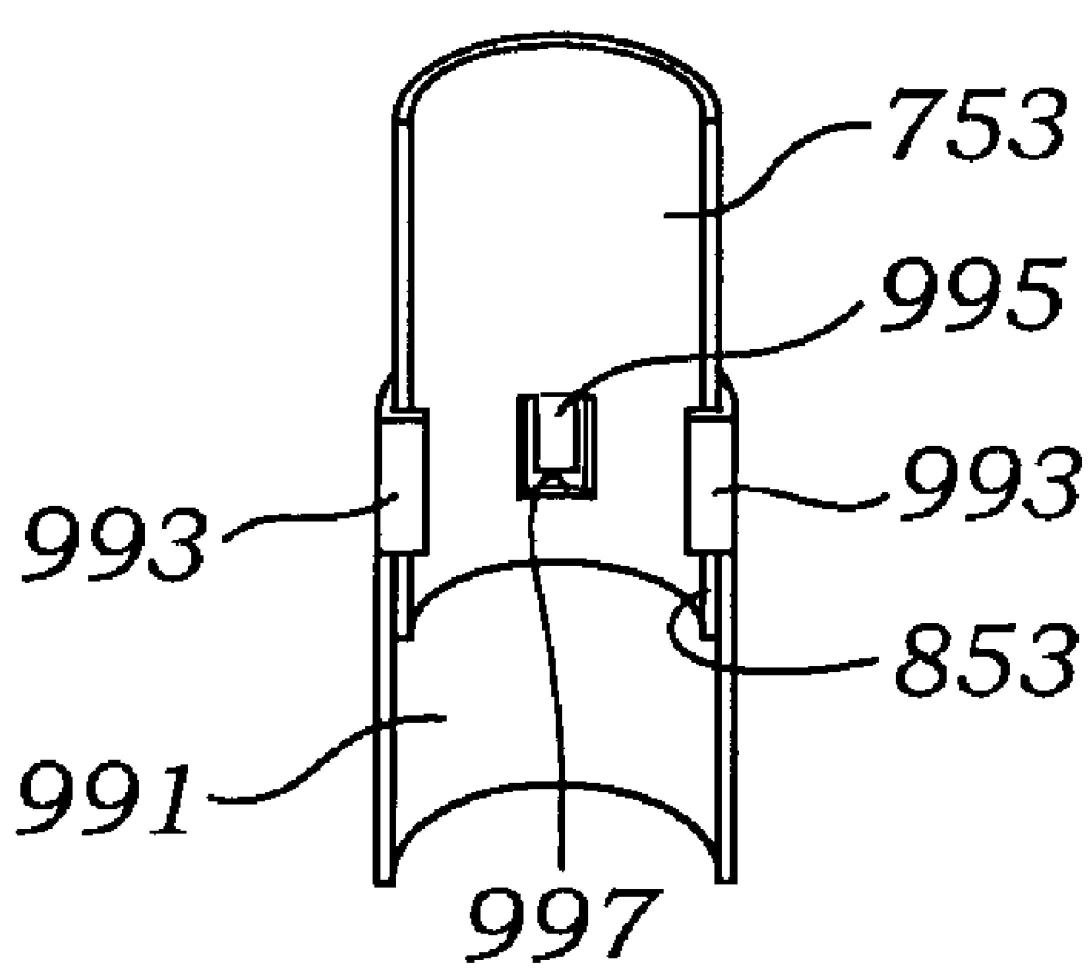
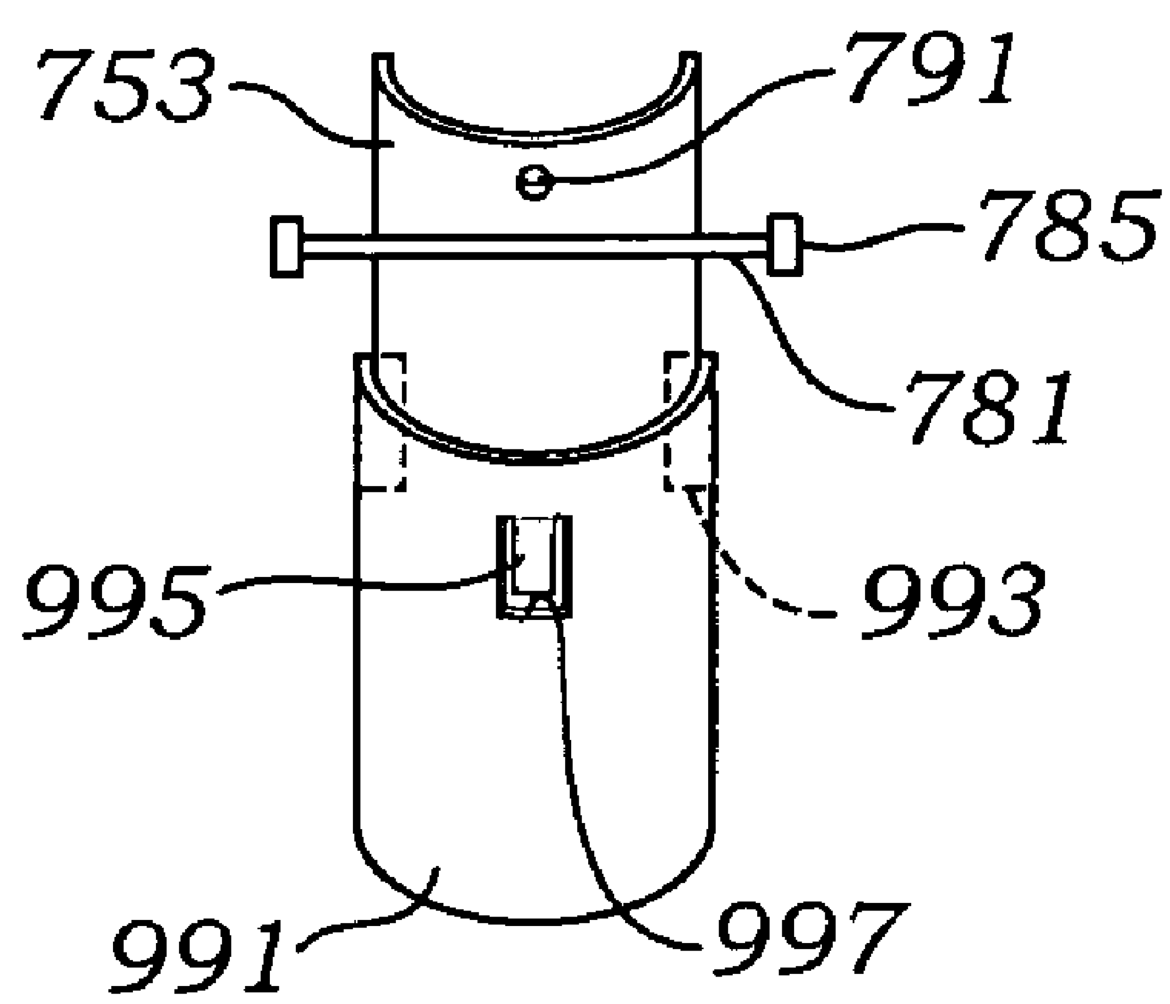


Fig. 60



MINIMAL ACCESS LUMBAR DISKECTOMY INSTRUMENTATION AND METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part application of U.S. patent application Ser. No. 11/165,295 filed Jun. 22, 2005, which is a continuation-in-part of U.S. patent application Ser. No. 11/001,628 filed Nov. 30, 2004 now U.S. Pat. No. 7,173,240, which is a divisional application of U.S. patent application Ser. No. 10/280,624 filed Oct. 25, 2002, now U.S. Pat. No. 6,849,064, the entire contents of each of which are incorporated by reference herein.

FIELD OF THE INVENTION

The present invention relates to improvements in the field of minimal access lumbar posterior surgery and more particularly to instrumentation which allows for maximal access to the surgical field through the smallest possible incision. Greater access is allowed into the working field while enjoying the reduction of trauma and disturbance to surrounding tissues, which results in a reduced the time necessary to complete the operative procedure, increased safety of the procedure, and increased accuracy by providing an expanded working field.

BACKGROUND OF THE INVENTION

Microscopic Lumbar Diskectomy techniques were developed and championed by Dr. Robert Williams in the late 1970's and by Dr. John McCullough in the late 1980's and 1990's. For the first time since the advent of Lumbar Disc Surgery by Mixter and Barr in 1934 a method was introduced allowing Lumbar Disc Surgery to be performed through a small incision safely resulting in faster patient recovery and converting a two to five hospital stay procedure virtually to an outpatient procedure.

The special retractors developed by Drs. Williams and McCullough however were often difficult to maintain in optimum position and relied on the interspinous and supraspinatus ligaments for a counter fixation point severely stretching the structures. This stretching along with the effects of partial facectomy, diskectomy, removal of the ligamentum flavum and posterior longitudinal ligament contributed to the development of Post Diskectomy Instability. Taylor retractors were also used but were cumbersome, required larger incisions and often injured the facet joints.

Dr. William Foley in 1997 introduced a tubular system mated to an endoscope which he labeled a Minimal Endoscopic Diskectomy (MED) system. It featured sequentially dilating the Lumbar Paraspinous Muscles allowing a working channel to be advanced down to the level of operation through which nerve root decompression and Diskectomy Surgery could be performed with a small incision and less muscle trauma. Improvements were made by Dr. Foley in his second generation METRx system. However, there were several disadvantages to the MED and METRx systems.

In the MED and METRx systems, the cylindrical working channel considerably restricted visualization and passage of instruments. It also compromised the "angle of approach" necessary for safe usage of the operating instruments. This problem was proportionately aggravated with the long length of the tube. This compromised visualization contributed to the following problems, including nerve injury, dural tear, missed disc fragments, inadequate decompression of the lateral recess, increased epidural bleeding, difficulty controlling epidural bleeding, inadequate visualization of the neuroforamen, and inadequate decompression of neuroforamen.

The repetitive introduction of successively larger dilators caused skin abrasion with the potential for carrying superficial skin organisms down to the deeper tissue layers hypothetically increasing the risk of infection. The learning curve for operating in a two dimension endoscopic field proved to be arduous and contributed to the above complications.

The attempted use of the METRx system for more complex procedures such as fusion was further hazardous by inherent limitations.

Endius in September of 2000 then introduced a similar device which differed by having an expandable foot piece to allow greater coverage of the operative field. However, the enlarged foot piece was unwieldy and difficult to seat properly. Exposure of the angle of approach was also limited by having to operate through a proximal cylindrical tube with its limitations as described before. In comparison to the METRx system the working area was improved but access was again restricted by the smaller proximal cylinder.

Both systems offered endoscopic capability but many spine surgeons chose to use an operating microscope or loupes to maintain 3-Dimensional visualization rather than the depth impaired 2-Dimensional endoscopic presentation. Keeping debris off of the endoscopic lens has also proved to be a troubling challenge.

SUMMARY OF THE INVENTION

The system and method of the invention, hereinafter minimal incision maximal access system, includes a surgical operating system that allows for maximum desirable exposure along with maximum access to the operative field utilizing a minimum incision as small as the METRx and Endius systems. The minimal incision maximal access system disclosed offers advantages over the METRx and Endius systems in several respects. First, instead of multiple insertions of Dilating Tubes the Invention is a streamlined single entry device. This avoids repetitive skin surface entry. Second, the minimal incision maximal access system offers the capability to expand to optimum exposure size for the surgery utilizing hinged bi-hemispherical or oval Working Tubes applied over an introducer Obturator which is controllably dilated to slowly separate muscle tissue.

Third, the minimal incision maximal access system maximizes deeper end working and visualization area with maximum proximal access and work dimensions significantly greater than either the METRx or Endius devices and methods. Fourth, the minimal incision maximal access system provides expanded visual and working field to makes the operative procedure safer in application and shorten the surgeons's learning curve because it most closely approximates the open microdiskectomy techniques. Fifthly, the minimal incision maximal access system has a tapered ended Obturator which allows for tissue spread rather than muscle tissue tear and subsequent necrosis.

Sixth, the minimal incision maximal access system controls muscle oozing into the operative field which is controlled by simply opening the tubes further. This also thereby controls the bleeding by pressure to the surrounding tissues. Seventh, in contrast to the cylindrical tube based systems such as the METRx and Endius the minimal incision maximal access system offers a larger working area in proportion to the working depth. For the first time this allows for a minimal access technique to be applied to the large or obese patients. The enlarged footprint of the longer tubes in the minimal incision maximal access system is a major difference from any other minimal access system.

An eighth advantage of the minimal incision maximal access system is that ist expandable design allows for excellent exposure for more complex procedures such as fusion and instrumentation including TLIF, PLIF, and TFIF (Transfacet Interbody Fusion), as well as allowing application for anterolateral lumbar disc surgery. The minimal incision maximal access system can also be used for cervical surgery posteriorly (foraminotomy, lateral mass instrumented fusion) as well as anterior cervical diskectomy and fusion. The minimal incision maximal access system can also be used for anterior lumbar interbody fusion be it retroperitoneal, transperitoneal or laparoscopic.

A ninth advantage of the minimal incision maximal access system is that the medial oval cutout of the retractors, or sleeve forming the working tube, allows more central docking on the spine which is problematic for other devices. A medialized docking provides access for easier and better and safer dural retraction to address midline pathology. A tenth advantage is had by including an anti-reflective inner surface of the retractor sleeves which eliminates unwanted glare.

An eleventh advantage of the minimal incision maximal access system includes the slanted and contoured distal end of the retractor sleeve which allows minimal resistance for entry and advancement to the docking site. A twelfth advantage minimal incision maximal access system is the provision of a variety of retractor tips specific for different surgical procedures.

A thirteenth advantage of the minimal incision maximal access system is the provision of oval retractor sleeves for larger access requirements such as pedicle to pedicle exposure and especially in the case where pedicle screw instrumentation is to be applied. This minimizes unnecessary muscle spread by providing a smaller waist profile than a circular system. A fourteenth advantage of the minimal incision maximal access system is that the larger retractor sleeve also features one or two "skirts" to cover the lateral aperture created by the spread of the two retractor sleeves when opened. This prevents soft tissue and muscle ingress into the working cone. The skirts are attached to the working tube either at the hinge or on one of the two halves of the sleeve.

A fifteenth advantage of the minimal incision maximal access system is the provision of a modular design in which the retractor sleeves can be quickly removed, changed and reapplied. In this version the proximal port can also be modular and changeable to fit the needs of a specific surgical procedure. A sixteenth advantage of the minimal incision maximal access system is that the retractor sleeves can be made out of metal, ceramic or plastic, can be opaque or translucent, and can have tips of different shapes for different applications. A seventeenth advantage is the provision of snap lock connections of the major parts of the Invention provides for easy assembly and disengagement for cleaning and sterilization purposes.

Further, the Obturator is cannulated for carrying a central Guide Pin Passage. It has a Handle component which remains superficial to the skin. The obturator houses an internal hinge device which allows for spread of the two obturator tips.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention, its configuration, construction, and operation will be best further described in the following detailed description, taken in conjunction with the accompanying drawings in which:

FIG. **1** is a perspective view of a working tube with an angled upper section and shown in position with respect to an obturator insertable into and workable within the working tube;

FIG. **2** is a perspective assembled view illustrating the relative positions of the obturator and working tube;

FIG. **3** is a perspective assembled view illustrates the position of the obturator after it has been inserted into the working tube;

FIG. **4** is a view taken along line **4-4** of FIG. **2** and looking into the working tube of FIG. **1**;

FIG. **5** is a sectional view taken along line **5-5** of FIG. **2** and looking into the hinge of working tube of FIG. **1**, illustrating its hinge connections;

FIG. **6** is an side end view of the working tube of FIGS. **1-5** and illustrating predominantly one of the rigidly connected halves of the invention;

FIG. **7** is a side sectional view taken along line **7-7** of FIG. **6** and showing the internal bearing pivot;

FIG. **8** is a side sectional view taken along line **8-8** of FIG. **5** and illustrating a option for external bevel for the working tube;

FIG. **9** is a side view of the working tube of FIGS. **1-8** shown with the lower portions in parallel alignment and the upper portions angled with respect to each other;

FIG. **10** is a side view of the working tube as seem in FIG. **9** and shown with the lower portions in an angled relationship and the upper portions in a closer angled relationship with respect to each other;

FIG. **11** is a side view of the working tube as seen in FIGS. **9** and **10** and shown with the lower portions in a maximally angled relationship and the upper portions in parallel alignment signaling maximal spread of the lower portions in bringing the upper portions into parallel alignment;

FIG. **12** is a side view of the obturator of FIG. **1** and seen in an assembled view and emphasizing a through bore seen in dashed line format;

FIG. **13** is a side view of the obturator of FIG. **11** as seen in an assembled view but turned ninety degrees about its axis and emphasizing the through bore;

FIG. **14** shows a side view of the obturator **33** of FIG. **13** with the spreading legs in an angled apart relationship;

FIG. **15** is a sectional view taken along line **14-14** of FIG. **12** and gives a sectional view from the same perspective seen in FIG. **14**;

FIG. **16** is a view of the obturator similar to that seen in FIG. **15**, but turned ninety degrees along its axis and illustrates the wedge as having a narrower dimension to lend internal stability;

FIG. **17** is a closeup view of the external hinge assembly seen in FIG. **1** and illustrates the optional use of a plug to cover the exposed side of a circular protrusion;

FIG. **18** is a view taken along line **18-18** of FIG. **11** and illustrates the use of an optional skirt having flexible members which spread from an initial curled position to a straightened position to better isolate the surgical field;

FIG. **19** is a view of the lower tube hemicylindrical portions **65** and **69** in a close relationship illustrating the manner in which the skirts sections within their accommodation slots areas;

FIG. **20** is a cross sectional view of the a patient and spine and facilitates illustration of the general sequence of steps taken for many procedures utilizing the minimal incision maximal access system disclosed;

FIG. **21** illustrates a fascial incisor over fitting a guide pin and further inserted to cut through external and internal tissue;

FIG. 22 illustrates the assembled Working Tube—Obturator being inserted into the area previously occupied by the fascial incisor and advanced to the operative level lamina;

FIG. 23 illustrates the obturator **33** being actuated to a spread orientation to which automatically actuates the working tube to a spread orientation;

FIG. **24** is a view of the working tube **35** is in place and supported, held or stabilized in the field of view by a telescopy support arm and engagement, the opposite end of the stabilizing structure attached to the operating table;

FIG. **25** illustrates further details of the support arm seen in FIG. **24**, especially the use of a ball joint;

FIG. **26** illustrates a side view of the assembly seen in FIG. **25** is seen with an adjustable clamp operable to hold the working tube open at any position;

FIG. **27** is a top view looking down upon the adjustable clamp seen in FIGS. **25-26** and shows the orientation of the working tube and adjustable clamp in fully closed position;

FIG. **28** shows a variation on the obturator seen previously in FIG. **1** and illustrates the use of handles which are brought together;

FIG. **29** illustrates a further variation on the obturator seen previously in FIG. **1** and illustrates the use of a central ball nut;

FIG. **30** is a sectional view taken along line **30-30** of FIG. **29** and illustrates the use of a central support block to support the central threaded surface;

FIG. **31** is a top view of a thin, inset hinge utilizable with any of the obturators herein, but particularly obturators of FIGS. **1** and **29**;

FIG. **32** is a sectional view of the obturator of FIG. **1** within the working tube of FIG. **1** with the wedge **51** seen at the bottom of an internal wedge conforming space;

FIG. **33** illustrates the obturator seen in FIG. **32** as returned to its collapsed state.

FIG. **34** illustrates a top and schematic view of the use of a remote power control to provide instant control of the working tube using an adjustable restriction on the upper angled hemicylindrical portions of the working tube;

FIG. **35** is a view taken along line **35-35** of FIG. **34** and illustrating the method of attachment of the cable or band constriction;

FIG. **36** is a mechanically operated version of the nut and bolt constriction band seen in FIG. **25**;

FIG. **37** is an isolated view of two hemicylindrical tube sections shown joined in a tubular relationship and indicating at least a pair of pivot axes on each hemicylindrical tube section;

FIG. **38** is an isolated view of two hemicylindrical tube sections as seen in FIG. **38** which are angularly displaced apart about a shared first pivot axis on each of the hemicylindrical tube sections;

FIG. **39** is an isolated view of two hemicylindrical tube sections as seen in FIGS. **38** and **39** which are angularly displaced apart about a shared second pivot axis on each of the hemicylindrical tube sections;

FIG. **40** is a plan view of a given width supplemental side shield having a width of approximately the separation of the hemicylindrical tube sections as seen in FIG. **39**;

FIG. **41** is a top view of the supplemental side shield of FIG. **40**;

FIG. **42** is a pivoting thread support system in which a pair of opposing flank threaded members operate a pivoting support and are connected by a gear mechanism shown in exaggerated format to give single knob separation control;

FIG. **43** illustrates a surrounding frame system utilized to provide and enable pivoting and translation;

FIG. **44** illustrates a view looking down into the structure of FIG. **43** shows the overall orientation and further illustrates an optional securing tang;

FIG. **45** illustrates a simplified control scheme in which simplicity is emphasized over controllability with less moving parts and expense;

FIG. **46** illustrates a further embodiment of a manipulative structure which works well with the structure of FIG. **45**;

FIG. **47** illustrates another possible realization which combines the control mechanisms of selected portions of FIGS. **37-46**, combined with other possible options;

FIG. **48** illustrates a side view of the side shield seen in FIG. **47**;

FIG. **49** illustrates one possible configuration for a variable depth guide which is utilizable with any of the devices seen in FIGS. **37-46** or any other tubular, minimally invasive system;

FIG. **50** is a vertical plan view of an expandable frame system which uses detents to set the frame size and which uses an angular distribution system;

FIG. **51** is a top view of the system of FIG. **50** in an expanded position;

FIG. **52** is a side view of the system of FIGS. **50-51**;

FIG. **53** illustrates a top view double pivot hinge fitting and illustrating the gear surfaces;

FIG. **54** illustrates the action of the pivot hinge which produces an even angular deflection;

FIG. **55** illustrates a top view of a bookwalter device mounted atop a central hinge box seen in FIG. **53**;

FIG. **56** is a top view of a retractor system employing many of the components seen in FIGS. **50-52** for applying force from a distance;

FIG. **57** is a top view of a hemicylindrical retractor tube extension;

FIG. **58** is a side sectional view of the hemicylindrical retractor tube extension of FIG. **57** attached to the hemicylindrical tube seen in FIG. **52**;

FIG. **59** is a view looking down into the inside of the hemicylindrical retractor tube extension of FIGS. **57** and **58**; and

FIG. **60** is a view looking down onto the outside of the hemicylindrical retractor tube extension of FIGS. **57-59**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The description and operation of the minimal incision maximal access system will be best described with reference to FIG. **1** and identifying a general system **31**. System **31** includes an obturator **33** and a working tube **35**. The orientation of the obturator **33** is in a slightly displaced from a position of alignment with the working tube **35** for entry into working tube **35** and to provide the initial carefully controlled force for spreading the working tube **35**, as will be shown.

Obturator includes an upper control housing **37** and a pair of spreading legs **39** and **41**. The spreading legs **39** and **41** are seen as coming together to form a conical tip and thus have hemi-conical end portions. The spreading legs **39** and **41** over fit the attachment leg portions **43** and **45**, respectively. At the top of the upper control housing **37** a boss **47** surrounds and supports the extension of a control shaft **49**. a knurled thumb knob **50** sits atop the control shaft **49** to facilitate controlled turning of the control shaft **49** to control the degree of spreading of the spreading legs **39** and **41**. Thus spreading can be controlled independently of pressure applied along the length of the obturator **33**.

Below the upper control housing **37** is the bottom of the control shaft **49** which operates against a wedge **51**. The wedge **51** operates within a pair of opposing slots **52** in an upper portion **53** of the overfit attachment leg portions **43** and **45**. The lower ends of the overfit attachment leg portions **43** and **45** include insertion tangs **55** which fit within insertion slots **57** of the spreading legs **39** and **41**. The overfit attachment leg portions **43** and **45** are pivotally attached to the upper control housing **37** internally by pivot blocks **59** which fit within access apertures **60**.

The working tube **35** has a first lower extending connection tang **61** and a second lower extending connection tang **63**. First lower extending connection tang **61** connects into a slot **64** of a lower tube hemicylindrical portion **65**. The first lower extending connection tang **61** is fixed to an upper angled hemicylindrical portion **67**. The second lower extending connection tang **63** connects into a slot **68** of a lower tube hemicylindrical portion **69**. Second lower extending connection tang **61** is fixed to and an upper angled hemicylindrical portion **71**. The upper angled hemicylindrical portion **67** has a reinforced wear plate **73** for applying upper pressure and force on the upper angled hemicylindrical portions **67** and **71** toward each other to cause the first and second lower extending connection tangs **61** & **63** and their connected lower tube hemicylindrical portions **65** and **69** to be urged away from each other.

At the side of the working tube **35** at the transition between the upper angled hemicylindrical portions **67** and **71** and a point just above the first and second lower extending connection tangs **61** & **63** is an external hinge assembly **77**. Hinge assembly **77** may include an optional first guide plate **79** and first circular protrusion **81** attached to upper angled hemicylindrical portions **67**, and a first slotted plate **83** positioned adjacent to first guide plate **79** and having a slot partially surrounding the circular protrusion **81**.

Upper angled hemicylindrical portion **71** has a pair of spaced apart facing surfaces facing a matching pair of facing surfaces of the upper angled hemicylindrical portion **67**, of which a dividing line **85** is seen. Upper angled hemicylindrical portions **67** and **71** are be brought together to cause the first and second lower extending connection tangs **61** & **63** and their connected lower tube hemicylindrical portions **65** and **69** to spread apart.

In the View of FIG. **1**, the first and second lower extending connection tangs **61** & **63** are shown in a spread apart relationship. a locking pin **87** is seen which can be used to engage angularly spaced apart apertures in the circular protrusion **81** to provide a detent action to hold the working tube **35** in various degrees of spread. Also seen is a slight exterior bevel **89** on the lower tube hemicylindrical portions **65** and **69**.

Note the angled separation of the upper angled hemicylindrical portions **67** and **71** and exposing opposing surfaces **91**. The angle of the opposing surfaces **91** equals the angle of spread of the first and second lower extending connection tangs **61** & **63**.

Referring to FIG. **2**, a perspective assembled view illustrates the relative positions of the obturator **33** and

working tube **35** in a position for the obturator **33** to be inserted into the working tube **35** and before any spreading takes place.

Referring to FIG. **3**, a perspective assembled view illustrates the position of the obturator **33** after it has been inserted into the working tube **35** and again before any spreading takes place. Note that the pivot axes of the first and second lower extending connection tangs **61** & **63** are on par with the pivot axes of the insertion tangs **55**. The tip of the obturator **33** extends slightly beyond the bottom most part of the working tube **35** so that the completed assembly can be smoothly urged past muscle and other tissue.

Referring to FIG. **4**, a view taken along line **4-4** of FIG. **1** is a view looking down into the working tube **35**. Other features seen include a wear plate **93** located on the upper angled hemicylindrical portion **71**. In both of the wear plates **73** and **93** a universal port **94** is provided as a bore for insertion of a tool or lever to assist in bringing the upper angled hemicylindrical portions **67** and **71** into a tubular relationship. Further, an identical hinge assembly **77** on the side opposite that seen in FIG. **1** is shown with the same numbering as the components which were seen in FIG. **1**.

Also seen are a pair of opposing surfaces **95** on upper angled hemicylindrical portion **71** and a pair of opposing surfaces **97** on upper angled hemicylindrical portion **67**. Also seen is a central working aperture **99**.

Referring to FIG. **5**, a view taken along line **5-5** of FIG. **1** is a sectional view looking down into the working tube **35**. The connectivity of the structures seen in FIG. **4** are emphasized including the connection of circular protrusion **81** to the upper angled hemicylindrical portion **71**, and the connection of first slotted plate **83** to upper angled hemicylindrical portion **67**, and which is indicated by the matching section lines Further, an identical hinge assembly **77** on the side opposite that seen in FIG. **1** is shown with the same numbering as the components which were seen in FIG. **1**.

Referring to FIG. **6**, a view of one end of the working tube **35** illustrates predominantly the second angled half portion **63**. Elements seen in FIGS. **1** and **2** are made more clear in FIG. **3**.

Referring to FIG. **7**, a side sectional view taken along line **7-7** of FIG. **6** and shows the internal bearing pivot consisting of a slightly greater than hemispherical side bump projection **101** located on upper angled hemicylindrical portion **71**, and a slightly less than hemispherical side circular groove **103** located on upper angled hemicylindrical portion **67**. Also seen is the interconnect slots **64** and **68** as well as the first and second lower extending connection tangs **61** and **63**. In the showing of FIG. **7** an external bevel **105** is utilized

Referring to FIG. **8**, a side semi-sectional view taken along line **8-8** of FIG. **5** illustrates the integral connectivity of circular protrusion **81** with the upper angled hemicylindrical portion **71**. Seen for the first time in isolation are a pair of pin apertures **107** for engaging the locking pin **87**.

Referring to FIG. **9**, an illustration of a side plan view and in which the lower tube hemicylindrical portions **65** and **69** are in matching straight alignment and forming a lower tube shape, while the upper angled hemicylindrical portions **67** and **71** are angled apart.

Referring to FIG. **10**, a midpoint of movement is illustrates wherein the lower tube hemicylindrical portions **65** and **69** have begun to move apart widening the lower tube shape previously formed into an angled apart opposing hemicylindrical shape, while the upper angled hemicylindrical portions **67** and **71** are brought closer together to have a closer though angled apart an angled apart opposing hemicylindrical shape.

Referring to FIG. **11**, a completed movement, with respect to the view of FIG. **4** illustrates a state where the lower tube hemicylindrical portions **65** and **69** have moved apart to their maximum extent into a maximally angled apart opposing hemicylindrical shape, while the upper angled hemicylindrical portions **67** and **71** are brought completely together to form an upper tube shape. It is the position of FIG. **6** which is the ideal working position once the lower tube hemicylindrical portions **65** and **69** are within the body, and provides an expanded working field at the base of the working tube **35**. Surgical work is ideally performed through the upper, abbreviated axial length tube shape formed by the upper angled hemicylindrical portions **67** and **71**.

Referring to FIG. **12**, a side view of the obturator **33** of FIG. **1** is seen in an assembled view and emphasizing in dashed line format a through bore **111** which extends though the obturator **33** from the knurled knob **50** through to the tip of the pair of spreading legs **39** and **41**.

Referring to FIG. **13**, a side view of the obturator **33** of FIG. **11** is seen in an assembled view but turned ninety degrees about its axis, and agin emphasizing in dashed line format the through bore **111** which extends though the obturator **33** from the knurled knob **50** through to the tip of the pair of spreading legs **39** and **41**. It is from this position that further actuation will be illustrated.

Referring to FIG. **14**, a side view of the obturator **33** of FIG. **13** is seen but with the spreading legs **39** and **41** in an angled apart relationship. An optional support **112** is supported by the upper control housing **37** to enable independent support and location of the obturator **33** should it be needed. Once the knurled knob **50** is turned, the wedge **51** seen in FIG. **1** is driven downward causing the spreading of the spreading legs **39** and **41**.

Referring to FIG. **15**, a sectional view taken along line **14-14** of FIG. **12** gives a sectional view from the same perspective seen in FIG. **14**. Pivot blocks **59** are seen as having pivot bores **113** which enable the upper portions **53** to pivot with respect to the upper control housing **37** and which enable the downward movement of the wedge **51** to translate into a spreading of the spreading legs **39** and **41**.

As can be seen, the knob **50** and control shaft **49** and the wedge **51** have the through bore **111**. In the configuration shown, the control shaft **49** includes a threaded portion **113** which engaged an internally threaded portion **115** of an internal bore **117** of the upper control housing **37**. The boss **47** is shown to be part of a larger insert fitting within a larger fitted bore **119** within the upper control housing **37**. This configuration pushes the wedge **51** downwardly against an internal wedge conforming space **123** to cause the insertion tangs **55** and upper portions **53** to spread apart. The wedge conforming space **123** need not be completely wedge shaped itself, but should ideally have a surface which continuously and evenly in terms of area engages the wedge **51** to give even control. Further, the wedge **51** can be configured to be rotatable with or independently rotationally stable with respect to the control shaft **49**. As can be seen, the through bore **111** continues below the internal wedge conforming space **123** as a pair of hemicylindrical surfaces **125** in the upper portion **53**, as well as a pair of hemicylindrical surfaces **127** in the pair of spreading legs **39** and **41**.

Referring to FIG. **16** a view of obturator **33** similar to that of FIG. **15**, but turned ninety degrees along its axis is seen. In this view, the wedge **51** is seen as having a narrower dimension to lend internal stability by narrowing the bearing area of the wedge **51** action in opening the pair of spreading legs **39** and **41**.

Referring to FIG. **17**, a closeup view of the external hinge assembly **77** seen in FIG. **1** illustrates the optional use of a plug **131** to cover the exposed side of the circular protrusion **81**.

Referring to FIG. **18**, a view taken along line **18-18** of FIG. **11** illustrates a view which facilitates the showing of an optional skirt, including a skirt section **133** welded or otherwise attached to lower tube hemicylindrical portion **65**, and a skirt section **133** welded or otherwise attached to lower tube hemicylindrical portion **69**. The skirts sections **133** and **135** are made of thin flexible metal and interfit within a pair of accommodation slots **137** and **139**, respectively.

Referring to FIG. **19**, a view of the lower tube hemicylindrical portions **65** and **69** in a close relationship illustrates the manner in which the skirts sections **133** and **135** fit within the accommodation slots **137** and **139** when the lower tube hemicylindrical portions **65** and **69** are brought together to a circular configuration.

Referring to FIG. **20**, a cross sectional view of the a patient **151** spine **153** is shown for illustration of the general sequence of steps taken for any procedure utilizing the minimal incision maximal access system **31**. There are several procedures utilizable with the minimal incision maximal access system **31**. Only a first procedure will be discussed using illustrative figures. Other procedures will be discussed after minor variations on the minimal incision maximal access system **31** are given below.

Procedure I: Diskectomy and Nerve Decompression

The patient **151** is placed prone on radiolucent operating table such as a Jackson Table. The patient **151** is then prepared and draped. The operative area is prepared and localized and an imaging device is prepared. A guide pin **155** is insert through the patient's skin **157**, preferably under fluoroscopic guidance. In the alternative and or in combination, the patient **151** skin can be incised with a scalpel. Other features in FIG. **20** include the dural sac **159**, and ruptured intervertebral disc **161**.

Referring to FIG. **21**, a fascial incisor **169** over fits the guide pin **155** and is further inserted to cut through external and internal tissue. The fascial incisor **169** is then removed while the guide pin **155** is left in place. Next, using the obturator **33**, the surgeon clears the multifidus attachment with wig-wag motion of the obturator **33** tip end. Next the obturator **33** is actuated to gently spread the multifidus muscle, and then closed.

Referring to FIG. **22**, next the assembled Working Tube **35**—Obturator **33** is inserted into the area previously occupied by the fascial incisor **169** and advanced to the operative level lamina and remove the obturator **33**. As an alternative, and upon having difficulty, the obturator **33** could be initially inserted, followed by an overfit of the working tube **35**. In another possibility, a smaller size of obturator **33** and working tube **35** or combination thereof could be initially utilized, followed by larger sizes of the same obturator **33** and working tube **35**. The assembled Working Tube **35**—Obturator **33** in place is shown in FIG. **22** with the working ends very near the spine.

Referring to FIG. **23**, the obturator **33** is actuated to a spread orientation, which automatically actuates the working tube **35** to a spread orientation. Spread is had to the desired exposure size. The obturator **33** is thin actuated to a closed or non-spreading position. The obturator and working tube is then again advanced to dock on the spine. The working tube **35** is then fixed to assume an open position either by utilization of the locking pin **87** or other fixation device to cause the working tube **35** to remain open. Then, once the working tube **35** is locked into an open position, the obturator **33** is actuated to a closed or non-spread position and gently removed from the working tube **35**.

Referring to FIG. **24**, the working tube **35** is in place. The working tube **35** may be secured by structure ultimately attached to an operating table. The working tube **35** may be held or stabilized in the field of view by a support **181** which may have an engagement sleeve **183** which fits onto the working tube. As can be seen, the operative field adjacent the spine area is expended even though the incision area is limited. The deeper a given size of working tube **35** is inserted, the smaller its entrance area. After the working tube **35** is stabilized, the surgeon will typically clear the remaining multifidus remnant at the working level and then set up and insert an endoscope or use operating microscope or loupes. The surgeon is now ready to proceed with laminotomy.

Referring to FIG. **25**, further detail on the support **181** and engagement sleeve **183** is shown. A base support **185** may support a ball joint **187**, which may in turn support the support **181**. The support **181** is shown as supporting a variation on the engagement sleeve **183** as a pivot point support engagement end **188** having arm supports **189** and **191**. The arm supports **189** and **191** engage the external pivot structure on the working tube **35** which was shown, for example, in FIG. **1** to be the external hinge assembly **77**.

As a further possibility, the upper angled hemicylindrical portions **67** and **71** are shown as being engaged about their outer periphery by an adjustable clamp **195**. Adjustable clamp **195** includes a band **197** encircling the upper angled hemicylindrical portions **67** and **71**. The ends of band **197** form a pair of opposing plates **199** and are engaged by a nut **201** and bolt **203** assembly.

Referring to FIG. **26**, a side view of the assembly seen in FIG. **25** is seen with the adjustable clamp **195** operable to hold the working tube **35** open at any position. Referring to FIG. **27**, a top view looking down upon the adjustable clamp **195** seen in FIGS. **25-27** shows the orientation of the working tube **35** and adjustable clamp **195** in fully closed position. When used in conjunction with the adjustable clamp **195**, the Reinforced wear plates **73** and **93** are eliminated so as to provide a smooth interface against the exterior of the upper angled hemicylindrical portions **67** and **71**.

Referring to FIG. **28**, a variation on the obturator **33** is seen. An obturator **215** has handles **217** and **219** which operate about a pivot point **221**. A working tube **222** is somewhat simplified but is equivalent to the working tube **35** and is shown as including upper angled hemicylindrical portions **67** and **71**. Handle **219** has a ratchet member **223**, with ratchet teeth **225**, extending from it and a latch **227** pivotally connected about pivot point **229** to handle **217**.

Referring to FIG. **29**, a variation on obturator **33** is seen as an obturator **241** having an upper housing **243**, control shaft **245** having
a threaded section **247** and operating through a ball nut **249**. A wedge **251** is extendable down through an operation space made up of a half space **253** in a leg **255** and a half space **257** in a leg **259**. Hinge structures **261** are shown attaching the legs **255** and **259** to the upper housing **243**. A through bore **111** is also seen as extending from the knob **261** through to the bottom of the wedge **251**. An access groove **263** is carried by the leg **259** while An access groove **263** is carried by the leg **259** while an access groove **265** is carried by the leg **255**.

Referring to FIG. **30**, a sectional view taken along line **30-30** of FIG. **29** illustrates the use of a central support block **271** to support the a central threaded surface **273** and the legs **255** and **259**.

Referring to FIG. **31**, a view of a thin, inset hinge **281** utilizable with any of the obturators, but particularly obturators **33** and **241**, is shown. In the case of obturator **33**, by way of example, upper portions **53** accommodate control shaft **49** with its through bore **111**. Inset hinge **281** may be have an inset **283** and secured with machine screws **285**. Inset hinge **281** may be made of a "living hinge" material such as a hard plastic, or it can have its operations base upon control bending of a pre-specified length of steel, since the angle of bend is slight. The connection between the upper portions **53** and the upper control housing **37** may be by any sort of interlocking mechanism, the aforementioned pivot blocks **59** or other mechanism.

Referring to FIG. **32**, a sectional view of the obturator **33** within the working tube **35** is seen. The wedge **51** is seen at the bottom of the internal wedge conforming space **123**. Once the spreading of the working tube **35** is accomplished the working tube **35** is kept open by any of the methods disclosed herein. Also seen is a pivot ball **116** to allow the control shaft **49** to turn with respect to the wedge. The pivot ball will continue to support a central aperture bore **111**. Once the working tube **35** is stabilized in its open position, the obturator **33** is returned to its collapsed state as is shown in FIG. **33**.

Provision of electromechanical power to the operation of the working tube **35** can provide a surgeon an additional degree of instant control. Referring to FIG. **34**, a top and schematic view of the use of a remote power control to provide instant control of the working tube **25**, similar to the view seen in FIG. **25** illustrates the use of a remote annular control cable **301** using an internal cable **303** which is closely attached using a guide **305** and which circles the upper angled hemicylindrical portion **67** and **71**, terminating at an end fitting **307**.

The annular cable **301** is controlled by a BATTERY MOTOR BOX **311** having a forward and reverse switch **313** (with off or non actuation being the middle position). This enables the surgeon to expand the surgical field as needed and to collapse the surgical field to focus on certain working areas. BATTERY MOTOR BOX **311** is configured with gears to cause the cable **303** to forcibly move axially within the annular cable **301** to transmit mechanical power to the working tube **35**.

Referring to FIG. **35**, a view taken along line **35-35** of FIG. **34** illustrates how the cable **303** is held in place and a closeup of the end termination **307**.

Referring to FIG. **36**, a mechanically operated version of the nut **201** and bolt **203** constriction band seen in FIG. **25**. The mechanical power linkage can be provided remotely as by a rotating annular cable, but the basic mechanical setup shown illustrates the mechanical principles. On the bolt **203**, a gear head **325** is placed, either by attachment or by the provision of a threaded member and gear head made together. A second gear head **327** is utilized to show the possibility of providing a right angle power take-off in the event that the power connection interferes with the area around the surgical field. A shaft **329** extends from a BATTERY MOTOR BOX **331**. The BATTERY MOTOR BOX **331** has a forward and reverse switch **333**, (with off or non actuation being the middle position). Shaft **329** could be flexible and connected directly into axial alignment with the threaded member of bolt **201** or an integrally formed threaded member.

Advantages Over Existing Surgical Techniques

In terms of general advantages, there are differences between the minimal incision maximal access system **31**, and its components as described in all of the drawings herein (but which will be referred throughout herein simply as the minimal incision maximal access system **31**, or simply system **31**) and other devices and procedures.

1. With regard to the Traditional microdiskectomy technique, the minimal incision maximal access system **31** allows for at least the same, if not better visualization access of the operative field. System **31** offers the same 3-Dimensional work ability or, if preferred, an endoscope can be utilized. System **31** minimizes muscle injury with spread versus extensive cautery dissection. System **31** has clear advantage on the challenging obese and very large patient where the traditional microdiskectomy technique is almost impossible to be applied.
2. With regard to open pedicle screw insertion procedures, system **31** offers muscle approach minimizing muscle

devascularization and denervation. The traditional approach had required at least one level proximal and one level distal additional exposure causing extensive muscle injury often leading to "fibrotic" muscle changes resulting in chronic painful and stiff lower back syndrome. System **31** offers the most direct approach to the pedicle entry point selecting the avascular plane between the longissimus and multifidus muscles.

3. With regard to the Sextant Procedure, system **31** offers clear advantage over the Sextant procedure. First, the system **31** offers a procedure which is not a blind pedicle screw technique. System **31** can be applied to larger and more obese patients in which the Sextant procedure cannot be utilized. In this procedure using system **31** oosterolateral fusion can be performed along with insertion of the pedicle screws. The sextant procedure is strictly a tension band stabilization.

In general, the components of the minimal incision maximal access system **31** are very simple the hemispherical shapes used for the working tube can be round or oval. A keying system can be had to align the obturator **33** to the working tube **35**. In the case of an oval system, the alignment would be automatic.

The minimal incision maximal access system **31** is a modular system with interchangeable parts for both the working tube **35** and the obturator **33**. The guide Pin **155** is of simple construction, as is the fascial incisor **169**. The working tube **35** has a limited number of basic parts, and can be made in the simple, two main piece version of FIG. **28**, or the multi-piece version of FIG. **1**, which enables retractor-sleeve substitution. A hinge and stabilization mechanism completes the simplified construction.

The obturator **33** is also of simple construction, with upper control housing **37**, pair of spreading legs **39** and **41**, and an internal hinge, whether the pivot blocks **59** or hinge **281** and its ability to support a control shaft **49** having a bore **111** for a guide pin **155**. Guide pin **155** may preferably have a size of from about 0.3 mm to 0.40 mm diameter and 30 cm to 40 cm in length. The fascial incisor may preferably be cannulated for usage with the guide pin **155** and have a width of about 2 mm more than the associated retractor. The overall cutting head length of about 1.2 cm has a shape as indicated in the Figures and has a thickness slightly larger than that of the guide pin **155**.

The working tube **35** can have several variations and added details including the simplest shapes as dictated by intended usage. Working tube **35** can have a simple fluted hemi-tube shape or a Slanted box shape. Further, the possibility of a fluted oval shape is dictated when the approach is more angular. The working tube **35** can have an attachment for an endoscope. Working tube **35** can also have a non-symmetric appearance as by having longitudinal cross sectional shape with half of its shape being rounded and one half of its shape being rectangular or box shaped. This could also give rise to a similarly shaped obturator **33**. The working tube **35** should have an anti-reflective inner coating and may be of modular construction.

The preferred lower dimensions for the lower tube hemicylindrical portions **65** and **69** include an overall shape which is semi tubular round or oval and having a width of from about 1.6-3.0 cm and a length of from about 4.0-18 cm. Hemicylindrical portions **65** and **69** may have custom cut outs depending upon planned application.

The hinge assembly **77** may have male-female post or male-female dial lock design, as well as a hinge housing and a bias (by spring or other mechanism) to keep angular displaceable portions of the working tube **35** closed. a "universal" port provides a point of attachment of an endoscopic or stabilizer bar.

The obturator **33** may be any controlled opening device including a circular band or cable, force Plates, or a device attached to hinge assembly **77** or other hinge assembly.

All sleeve attachments including the attachable legs **39** and **41**, as well as the lower tube hemicylindrical portions **65** and **69** should be of the friction grip type or snap and lock type or other suitable connection method or structure.

Obturator **215** may have squeeze grip scissor style handles **219** and **217** and a controlled dilator. It may utilize an enclosed design with a handle cover having a no-slip surface. It may be attached to the hinge housing of the working tube or separate hinge housing. In fact, it may be of a design to be held in place solely by the working tube **35**. Ideally a cavity will be provided through the center axis to contain the shaft for the dilator mechanism if applicable.

The central bore **111** of the obturator **33** may have a diameter of from about 5-10 mm, depending upon the size of the obturator **33** utilized. Obturator **33** should be provided in various widths and length to match working tube. The working tips of the spreading legs **39** and **41** may be changeable according to surgical procedures as described in the operative procedures herein. It may have an inner chamber, or internal wedge conforming space **123** slanted in shape wider proximal and more narrow distal to accommodate the wedge **51**. The internal wedge conforming space **123** can be enclosed with expanding, contracting sleeve.

Other Procedures

Many other procedures can be facilitated with the use of the inventive minimal incision maximal access system **31** and methods practiced therewith. Procedure I, a diskectomy and nerve decompression procedure was described above with reference to the Figures. Other procedures are as follows:

Procedure II: Facet Fusion

1. Patient prone on Jackson Table with normal lordosis preserved. This can be increased by placing additional thigh and chest support to increase lumbar lordosis.

2. Insert percutaneous special guide pin perpendicular to the floor at a point 1 cm caudal to the Alar-Superior facet notch.

3. Apply a flag guide to a first guide pin **155** #1.

4. Measure skin to bone depth from the scale on guide pin **155** #1.

5. Slide drill guide mechanism on the flag guide to match the skin bone distance.

6. Insert guide pin **155** #2 through the drill guide to dock on the superior facet.

7. Make a small skin incision for the obturator **33**.

8. Working tube **35** should be small oval or round with medial cutout to maximally medialize the working tube **35**.

9. Advance the working tube **35** to the L5-S1 joint and dock.

10. Drill the guide pin across the joint medial to lateral, rostral to caudal. If in proper position, advance across the joint to engage the ala.

11. Drill across the joint with a cannulated drill.

12. Check depth flouroscopically and measure.

13. Pick appropriate screw length.

14. Insert specially designed facet screw and protective bracket, secure tightly.

Procedure III: Posterior Lumbar Interbody Fusion (PLIF)

1. First half of the procedure similar to microdiskectomy (Procedure I) except for the use of a larger diameter sized

working tube **35**. Use a 20-25 mm round or elliptical diameter working tube **35** with a medial cutout to allow docking as close to midline as possible.

2. Following diskectomy enlarge the laminotomy to accommodate the tools use for the specific PLIF such as Brantigan cage or Tangent.

Procedure IV: Transfacet Interbody Fusion (TFIF)

1. Follow the same procedure as the PLIF in terms of selecting and inserting the Working Tube **35**.

2. Following the diskectomy, resect the facet joint.

3. Approach the posterolateral disc space through the medial ⅔ of the facet joint. Take care not to injure the exiting root above.

4. Proceed with Brantigan cage instruments and interbody cages.

Procedure V: Pedicle Screw Instrumentation Technique

1. Place the patient **151** Prone position on a Jackson Table.

2. Guide pin **155** is docked on facet joint angled 30 degree lateral to medial in the plane between the longissimus muscle longitudinally and multifidus muscle medially.

3. Make skin incision.

4. Fascial incisor introduction.

5. Introduce the obturator **33** working tube **35** assembly between the longissimus and multifidus and progressively open the obturator **33** tip ends of the legs **39** and **41**, gradually reaching from the joint above and the joint below.

6. Advance the working tube **35** and retract the obturator **33**.

7. Use the elliptical Working Tube size 2.5 cm wide and open up to 5 cm.

Procedure IV: Anterior Lateral Lumbar Diskectomy Fusion

1. Mid lateral decubitus position left side up. Place a "waist roll" to prevent sag of the mid lumbar spine.

2. Identify proper level of surgery fluoroscopically.

3. Insert a guide pin **155** #1 percutaneously into the superior facet perpendicular to the spine.

4. Measure depth skin to joint on the scaled guide pin **155** #1.

5. Insert cannulated flag guide over guide pin **155** #1.

6. Slide the drill guide to match the depth.

7. Insert a guide pin **155** #2 down to the disc space.

8. Make skin incision and insert fascial cover.

9. Insert the working tube **35** and Obturator **33** combination.

10. Progressively dilate the obturator **33**.

11. Advance the working tube **35**.

12. Perform anterolateral diskectomy and interbody fusion as taught above.

13. Use a round or oval shaped retractor or lower tube hemicylindrical portion **65** and **69** as inserts preferably with distal end cutouts in each.

Procedure VII: Posterior Cervical Foramenotomy and Lateral Mass Plating

1. The patient is placed in a prone position on a Jackson table.

2. Fluoroscopic identification of the level of surgery is had.

3. Percutaneously insert guide pin **155** with AP and lateral fluoroscopic views.

4. Make the initial skin incision.

5. Apply the working tube **35** with obturator **33** into the incision.

6. Perform slow dilation of the muscle.

7. Advance the working tube **35** and collapse and remove the obturator **33**.

8. Proceed with surgery. Type of sleeve or lower tube hemicylindrical portion **65** should be round or oval with slanted and to match the slanted lamina.

9. For application for Lateral mass plating use an oval working tube **35** for a greater exposure.

Procedure VIII: Anterior Cervical Diskectomy Fusion

1. Begin with standard anterior cervical diskectomy fusion approach with a incision on the left or right side of the neck.

2. Blunt finger dissection is performed between the lateral vascular structures and the medial strap muscle and visceral structures down to the prevertebral fascia.

3. Establish the correct level to be operated on fluoroscopically and the guide pin **155** inserted into the disc.

4. Apply the working tube **35** and obturator **33** combination and dock at the proper level of the anterior spring.

5. Open the working tube **35** and obturator **33**.

6. Mobilize longus colli muscle.

7. Use special Bent Homen Retractor specifically design to retract the longus colli.

8. Proceed with surgery.

Procedure IX: Anterior Lumbar Interbody Fusion

1. Begin with the standard approach whether it is retroperitoneal, transperitoneal or laparoscopic.

2. Apply the special anterior lumbar interbody fusion working tube **35** and obturator **33**. This is a design with a medial lateral opening. It is oval shape and preferably with skirts **133** and **135**. The distal end of the retractor sleeve is slightly flared outward to retract the vessels safely. There is a skirt **133** or **135** applied to the cephalad side and possibly to the caudal side.

3. With the vessels and the abdominal contents safely retracted out of harms way, proceed with diskectomy and fusion.

One of the aspects emphasized up to this point for the system **31** is structure and circumstance to minimize the upper entry point of the surgery while providing an expanded working area at the distal end of the tube. Structures which achieve this geometry have been shown, and include a flared upper end so that the aperture remains open regardless of the angle of spread.

In other applications it is permissible to expand the aperture opening at the top of the working sleeve assembly. Expansion can be for the purposes of introducing further working devices into the working tube, as well as to expand and protect the visual field. For example, further working devices may include implant tools and their held implants, tools to insert plates and screws, and tools to manipulate all of these into their final positions.

Visual field protection can be introduced where the surrounding tissue may tend to flow, move or obstruct the surgical working field. Where the bottom-most portions of the spread apart hemicylindrical tube are spread apart, tissue tends to enter the space between the bottom parts of the tube. Additional guarding structure needs to be introduced.

a description of the desired articulation of what is hereinafter referred to as a working tube assembly **417**, and including the working tube hemicylindrical portions is begun with respect to FIG. **37**. The designation of working tube assembly **417** refers to all of the tube structures seen in the earlier FIGS. **1-36** and as seen in any of the following Figures. FIG. **37** is an isolated view of two hemicylindrical tube sections shown joined in a tubular relationship and indicating at least a pair of pivot axes on each hemicylindrical tube section.

At the top of the structure shown in FIG. **37** a dashed line indicates an optional fluted structure **419**. Fluted structure is omitted from the drawings for FIGS. **37-49** in order that the views from the top will not be obscured. The optional fluted opening **419** and is often employed both to maintain the visual field upon opening, as well as to make it easier to add instrumentation into the surgical field. This structure is recommended, as well as all reasonable accommodation to facilitate its use.

a first hemicylindrical tube **421** is shown in alignment with a second hemicylindrical tube **423**. Rather than having the upper ends flared out to maintain a circular visual field on a full open position, a clearance notch **425** is provided in first hemicylindrical tube **421**, while a clearance notch **427** is provided in second hemicylindrical tube **423**.

The lowermost extent of the clearance notches **425** and **427** coincide with an upper pivot axis **431** of first hemicylindrical tube **421** and upper pivot axis **433** of first hemicylindrical tube **421**. The pivot axes **431** and **433** may include supports either derived from structures going into or out of the first and second hemicylindrical tubes **421** and **423**. In the view of FIGS. **37**-**39**, the structures seen facing the viewer are repeated on the opposite side. Thus, pivot axes **431** and **433** are also located on the side opposite that seen in FIGS. **37**-**39**. The same is true for all of the numbered structures. In this position, the simultaneous pivoting about the pivot axes **431** and **433** of the first and second hemicylindrical tubes **421** and **423** will not cause interference by portions of the first and second hemicylindrical tubes **421** and **423** which would otherwise interfere.

Further, a lower pivot axis **435** is provided below the upper pivot axis **431** of first hemicylindrical tube **421**. Similarly, a lower pivot axis **437** is provided below the upper pivot axis **433** of second hemicylindrical tube **423**. The geometry and pivot points having been identified, double headed arrows illustrate that the pivot points should be able to move toward and away from each other. Ideally, the only limitation should be the interference from the lower ends of the first and second hemicylindrical tubes **421** and **423** with each other. Where the mechanism for moving the first and second hemicylindrical tubes **421** and **423** has maximum independence, secondary considerations of interference are eliminated and only the primary interference between the first and second hemicylindrical tubes **421** and **423** will remain. Where the control mechanism for movement is lesser than that which allows maximum independence, savings can be had in terms of complexity of the mechanism at the expense of the freedom of movement.

FIG. **37** illustrates the first and second hemicylindrical tubes **421** and **423** in a closely aligned relationship where the upper pivot axis **431** is closest to the upper pivot axis **433** and where the lower pivot axis **435** is closest to the lower pivot axis **437**. This is the position expected to be used for entry into the body of the patient, especially along with a guide (to be shown) which will be located within and extending below the assembled and parallel linear tube formed by first and second hemicylindrical tubes **421** and **423** to provide a reduced insertion resistance.

Ideally, the first and second hemicylindrical tubes **421** and **423** will be inserted as shown in FIG. **37** and then manipulated to a position shown in FIG. **38**. FIG. **38** is an isolated view of two hemicylindrical tube sections as seen in FIG. **38** which are angularly displaced apart about a shared first pivot axis on each of the hemicylindrical tube sections. The position in FIG. **38** is characterized by the fact that upper pivot axes **431** and **433** have the same separation as seen in FIG. **37**, but in which the lower pivot axes **435** and **437** have moved apart. The position seen in FIG. **38** will be likely achieved just after insertion and in which the internal tissues have been pushed apart. Depending upon the surgical procedure, the first and second hemicylindrical tubes **421** and **423** will be chosen based upon length, so that the lower end will be at the correct height for the tissues to be viewed, manipulated and treated. The action can continue until the lower ends of the first and second hemicylindrical tubes **421** and **423** are sufficiently spaced apart for view and manipulation of the tissues between and adjacent the lower ends. If there is a sufficient viewing opening based upon the original distance of separation of the upper pivot axes **431** and **433**, the procedure may continue through an aperture about the same size of the tube shape seen in FIG. **37**.

Where more of an opening is needed, the first and second hemicylindrical tubes **421** and **423** upper pivot axes **431** and **433** can move more widely apart until a position such as that seen in FIG. **39** is achieved. FIG. **39** is an isolated view of the two first and second hemicylindrical tubes **421** and **423** which are angularly displaced apart about a shared second pivot axis on each of the hemicylindrical tube sections. It should be emphasized that the position seen in FIG. **39** is a position where both the first and second hemicylindrical tubes **421** and **423** are parallel and separated from each other, but this need not be the case. From the position seen in FIG. **38**, the upper pivot axes **431** and **433** can be moved apart from each other while the lower pivot axes **435** and **437** either remain a constant distance from each other or are brought together. This range of articulation described can be used to physically manipulates the tissues in contact with the first and second hemicylindrical tubes **421** and **423** for any number of reasons, including introduction of further instruments if necessary, as well as to react to changing conditions of tissue at the lower tube.

In both FIGS. **38** and **39** a pair of opposing edges **439** can be utilized to support structures introduced between the first and second hemicylindrical tubes **421** and **423**. Other structures can be used including depressions, apertures and internal projections, such as hooks or latches. An internal structure within the first and second hemicylindrical tubes **421** and **423** would pose little risk of nick to the patient and can be designed to do nothing more than have a minimal interference effect with respect to the visual field.

As will be shown, a number of external structures can be employed to achieve the relative separation positions of the upper pivot axes **431** and **433**, as well as the lower pivot axes **435** and **437** that nearly any type of angle can exist on either side of a parallel relationship between the first and second hemicylindrical tubes **421** and **423**, but that most will be in a range of from a parallel relationship to some form of angular relationship seen in FIG. **38**, where the upper ends at the clearance notches **425** and **427** are closer together than the lower ends distal to the upper pivot axes **431** and **433** and lower pivot axes **435** and **437**.

One example of a side shield **441** is seen in FIG. **40**. FIG. **40** is a plan view of a given width supplemental side shield **441** having a width of approximately the separation of the hemicylindrical tube sections as seen in FIG. **39**, while accompanying FIG. **41** is a top view of the supplemental side shield **441** of FIG. **40** emphasizing its shape. The side shield **441** can be of any shape, but is shown in a rectangular shape to correspond with the first and second hemicylindrical tubes **421** and **423** in a parallel position as seen in FIG. **39**. The side shield **441** has a main portion which includes a first side **443** and a pair of lateral engagement portions **445**. The side shield **441** can depend from a number of other structures, but the side shield **441** seen in FIGS. **40** and **41** utilize an offset surfaces as engagement portions **445**. This geometry, will, absent any interfering structures which are attached to manipulate the first and second hemicylindrical tubes **421** and **423**, enable the side shield **441** to be introduced linearly from the top of first and second hemicylindrical tubes **421** and **423**. The introduction of side shield **441** may be guided somewhat into engagement by the clearance otches **425** and **427**. Much smaller engagement portions **445** could be used to engage the outer edges **439** of the first and second hemicylindrical tubes **421** and **423**, so long as the orientation is so as to protect the surrounding tissues. FIG. **41** emphasizes the geometry and shows a second side **447**.

In the orientation shown, the second side **447** would face toward the inside of the general tube formed in the orientation of FIG. **39**. If two of the side shields **441** were used, one on either side of the opening seen in FIG. **39**, the tube shape would be closed on both sides, and an oval viewing area would be formed. It should be emphasized that the side shield **441** can depend from any structure, and not just the opposing edges **439** seen in FIG. **39**. Structure used to manipulate the first and second hemicylindrical tubes **421** and **423** can be used to both guide and secure any side shield **443**.

In terms of a structure to manipulate the first and second hemicylindrical tubes **421** and **423**, it is preferable that the upper pivot axes **431** and **433** may be urged toward and away from each other independently of the urging of the lower pivot axes **435** and **437** toward and away from each other independently. a mechanism which would prevent all manipulations of the first and second hemicylindrical tubes **421** and **423** to a position of binding is desirable, but its complexity may obstruct the surgical field. For example, it would be good to have a mechanism which would prevent upper pivot axes **431** and **433** from moving away from each other while the lower pivot axes **425** and **437** are in their close proximity as depicted in FIG. **37**. In some cases operator knowledge and skill will probably be required.

In terms of supporting the upper pivot axes **431** and **433** and lower pivot axes **425** and **437**, the pivoting and movement may be passive with mechanisms to push or pull directly on the first and second hemicylindrical tubes **421** and **423** or structures which are mechanically attached. As an example of the use of force and movement urging at the pivot points, FIG. **42** illustrates one such system as a pivoting thread support system **551**. The gearing is shown as unduly expansive to illustrate simply the action, but in reality, several gears may be used.

Further, since the a pivoting thread support system **551** is viewed from the top, and as operating the upper pivot axes **431** and **433**, a similar arrangement would be used for the lower pivot axes **425** and **437**. a set of four pivot fittings **553** provide a threaded interior spaced apart from the first and second hemicylindrical tubes **421** and **423**, or fittings supporting the first and second hemicylindrical tubes **421** and **423**. The fittings **553** enable the first and second hemicylindrical tubes **421** and **423** to tilt while keeping the threaded apertures in alignment.

A first threaded member **555** has a pair of threaded areas in which the threads are oppose pitched, and a knob **558** for manually turning the thread member **555**. The threads engaging the fitting **553** of first hemicylindrical tube **421** are set to urge first hemicylindrical tube **421** away from second hemicylindrical tube **423**, at the same time that the same turning of the first threaded member engages fitting **553** of first hemicylindrical tube **423** set to urge first hemicylindrical tube **423** away from second hemicylindrical tube **421**. This means that the turning of first threaded member **555** in one direction urges the first and second hemicylindrical tubes **421** and **423** evenly away from each other, and alternatively, the turning of first threaded member **555** in the opposite direction urges the first and second hemicylindrical tubes **421** and **423** evenly toward each other.

Likewise, a second threaded member **557** has a pair of threaded areas in which the threads are oppose pitched. The threads engaging the fitting **553** of first hemicylindrical tube **421** are set to urge first hemicylindrical tube **421** away from second hemicylindrical tube **423**, at the same time that the same turning of the first threaded member engages fitting **553** of first hemicylindrical tube **423** set to urge first hemicylindrical tube **423** away from second hemicylindrical tube **421**, but in an oppose orientation than the threads of first threaded member **555**. This means that the turning of second threaded member **557** in the other direction (while the first threaded member **555** is turned in a first direction) urges the first and second hemicylindrical tubes **421** and **423** evenly away from each other. a pair of over sized gears, including a first gear **559** associated with the first threaded member **555**, and a second gear **561** associated with the second threaded member **557** act to cause the first and second threaded members **555** and **557** to move simultaneously and oppositely. a knob **563** is used to manipulate both the first gear **559**, which manipulates the second gear **561**. In a realization in which more gears **559** and **561** are provided, the size of the gears can be reduced and for each intermediate gear, the sense of the threaded members **555** and **557** will change from opposite to same.

Referring to FIG. **43**, a surrounding frame system **571** is seen which is utilized to provide and enable pivoting and translation. A surrounding frame **573** has an open slot **575** which accommodates a pair of pins **577** and **579** which preferably have some tracking along the slot **575** to insure that neither the first hemicylindrical tube **421** nor the second hemicylindrical tube **423** are able to turn within the frame **573**. The opposite side of the frame **573** will have a similar slot **575**. However, where the structures which engage the slot are especially over sized, or where the structural integrity is sufficient, only one slot need be used. The structural dependence on the frame **573** should be such that the two opposing first and second hemicylindrical tubes **421** and **423** will always oppose each other and cannot twist away from each other and can only pivot along their long axis.

a turn fitting **581** enables a threaded member **583** to turn while being axially fixed to the first hemicylindrical tube **421**. The threaded member **583** may be threadably engaged to an internal thread **585** at the end of the frame **573**. In this case a knob **587** is used to manually turn the threaded member **583** independently to move the first hemicylindrical tube **421** to the left or to the right. A turn fitting is a structure which holds the end of the threaded member and allows the threaded member **583** to urge the fitting forward or backward while continuing to turn.

In the alternative, knob **587** may have an internal thread, and turned with respect to the threaded member **583** draw the threaded member out of the frame **573**. In this case, a spring (as will be shown) could be used to help reverse this operation. Where the knob **587** is internally threaded, the end of the threaded member may be fixed directly to its first hemicylindrical tube **421**.

In sum, there are three ways to affect motion, preferably the internal threads **585** enable the threaded member **583** to turn to urge first hemicylindrical tube **421** in both directions with respect to the frame **573**. In the alternative, the threaded member **583** may act only to urge the first hemicylindrical tube **421**, and the tubes **421** and **423** may have another mechanism urging them apart or simply move apart based upon other forces or other structures present. Third, the threaded member **583** may have an end anchored to the first hemicylindrical tube **421** with an internally threaded surface inside knob **587** to enable the knob **587** to be turned to cause the length of threaded member **583** to be withdrawn from the frame **583**. A spring, or other fitting can be used to help reverse the direction of travel. All of the knobs and threaded members shown hereafter have the ability for all three modes of action.

Similarly, a turn fitting **591** enables a threaded member **593** to turn while being axially fixed to the second hemicylindrical tube **423**. The threaded member **593** threadably engaged to an internal thread **595** at the end of the frame **573**. a knob **597** is used to manually turn the threaded member **593** independently to move the second hemicylindrical tube **423** to the left or to the right.

Similarly, a second surrounding frame **573** has an open slot **575** which accommodates a pair of pins **601** and **603** having expanded heads which fit outside the slot **575** to provide tracking along the slot **575** to further insure that neither the first hemicylindrical tube **421** nor the second hemicylindrical tube **423** are able to turn within either of the frames **573**.

a turn fitting **611** enables a threaded member **613** to turn while being axially fixed to the first hemicylindrical tube **421**. The threaded member **613** is threadably engaged to an internal thread **615** at the end of the frame **573**. a knob **617** is used to manually turn the threaded member **613** independently to move the first hemicylindrical tube **421**, at its lower pivot axis **435** at the center of the pin **601**. Similarly, a turn fitting **621** enables a threaded member **623** to turn while being axially fixed to the second hemicylindrical tube **423**. The threaded member **623** threadably engaged to an internal thread **625** at the end of the lower located frame **573**. a knob **627** is used to manually turn the threaded member **623** independently to move the second hemicylindrical tube **423** to the left or to the right at its lower pivot axis **437** at the center of the pin **603**.

With the configuration of FIG. **43**, the position within the upper located frame **573** and separation of the pivot axes **431** and **433** (represented by the pins **577** and **589**) can be exactly specified. Likewise, the position within the lower located frame **573** and separation of the pivot axes **435** and **437** (represented by the pins **601** and **603**) can be exactly specified. In typical use, the knobs **617** and **627** and will be activated after insertion to achieve the configuration seen in FIG. **38**, and then followed by the use of the knobs **587** and **597** to achieve the configuration seen in FIG. **39**, if necessary. Thereupon the optional side shield **441** may be employed. Where a lesser separation than that seen in FIG. **39** is used, a narrower side shield **441** may be employed. In a surgical kit, several such shields **441** of different size and shape may be available.

Referring to FIG. **44**, a view looking down into the structure of FIG. **43** shows the overall orientation and further illustrates an optional securing tang **629** which may be used with either of the upper located or lower located frame **573**, and may be located in any position, or extended in any direction, to better enable the surgeon to stabilize and manipulate any of the assemblies **417**, **551** and **571** seen. Any structure can be used to help secure the frame **573** and or the first and second hemicylindrical tubes **421** and **423**. FIG. **44** is an equivalent view through the lower of the frames **573**, including the knobs **617** and **627** as the two frames **573** have equivalent action. Note that having complete control over both the separation, angular relationship, and position of the first and second hemicylindrical tubes **421** and **423** within the frame **573** will enable the surgical practitioner to position the line of sight of the working tube along the frame **573** length and to generally have complete control.

Also shown in FIG. **44** is an optional spring **630** which can be used to bias the force acting upon either of the first and second hemicylindrical tubes **421** and **423**, or it can be used to bias a knob **597** away from the frame **573**. Although shown as an option, the use of a spring **639** may contribute significantly where force is to be had in one direction only, as well as to lock a threaded member such as **593** into a turn fitting by keeping a pulling bias in place.

In some cases it may be desired to reduce the number of controls to accomplish certain objectives, such as simplicity, less controllability, less moving parts, inexpense, or the critical need for space about the upper part of any of the assemblies **417**, **551** and **571**. One example of an arrangement is seen in FIG. **45**. a frame **631** has an interior having one surface which may generally match one of the first and second hemicylindrical tubes **421** and **423**, and in this case first hemicylindrical tube **421**. The frame **631** may be attached to the first hemicylindrical tube **421** by tack welding or the like, or other means. a single threaded member **633** includes a knob **635**. a structure **637** can be either an engagement turning block to enable the threaded member **633** to both push and pull on the second hemicylindrical tube **423**, or it may simply be a wear block to allow the threaded member **633** to push against it and to protect the second hemicylindrical tube **423** from wear.

Because half of the tube assembly of first and second hemicylindrical tubes **421** and **423** is supported by the frame **631**, the second hemicylindrical tube **423** is left to move only slightly and assuming that FIG. **45** is an upper view and that the pivoting of the second hemicylindrical tube **423** is accomplished at a lower level, especially at the level of lower pivot axis **437**, the frame **631** is left to control second hemicylindrical tube **423** by simply pushing, or by pushing and pulling. Where structure **637** is a turning block, there is a bulbous expansion at the end of threaded member **633** which snaps into structure **637** as a turning block and is free to turn and both push and pull second hemicylindrical tube **423**. The threaded member **633** is threadably engaged into an internal threaded bore **639** within the frame **631**.

Referring to FIG. **46**, one embodiment of a manipulative structure which works well with the structure of FIG. **45** is shown. The structure shown is a partial section taken at the lower pivot axis level and includes means for pushing and pulling, or pushing alone. Preferably, when used with the structure of FIG. **45**, it will include pushing and pulling, especially if the structure of FIG. **45** performs pushing alone. Either of the structures in FIG. **43** at either the upper or lower pivot axis levels can be substituted for either of the structures shown in FIGS. **45** and **46** as the structures in FIG. **43** provide both pushing, pulling, pivoting and level support.

Where the structures of FIG. **45** provides both pushing and pulling, it can be used along with a second structures at the lower pivot axis as any structure which provides both pushing and pulling will also provide some pivoting support. Further, the structure shown in FIG. **46** is hinged to provide additional pivoting support. The structure of FIG. **46** can be used at either the upper pivot axes **431** and **433** or the lower pivot axes **435** and **437**. Both the structures of FIGS. **45** and **46** demonstrate clearly that lesser control structures than are shown in FIG. **43** can be used to control the first and second hemicylindrical tubes **421** and **423**, along with lesser control inputs, and less control specificity, but also with less moving parts and a lesser mechanical complexity.

Referring again to FIG. **46**, second hemicylindrical tube **423** is seen as tack welded to a reinforcement **651**. The purpose of reinforcement **651** is to provide an expanded thickness of material so that pivoting can occur closer to the edge **439** as is possible. It is further possible to continue the extent of the reinforcement **651** and its pivot point in the direction of first hemicylindrical tube **421** if the other geometries of the other components permit. Reinforcement **651** contains a pair of threaded bores **653**, each of which accommodates one of the threaded screws or bolts **655** shown. The bolts **655** each extend through one end of a "U" shaped fitting **657**, so that the reinforcement **651** and attached second hemicylindrical tube **423** pivots with respect to the fitting **657**. a threaded member **659** engaged an internal threaded bore **671**, and has a knob **673** for ease of manual operation.

The threaded member is connected to a turn fitting **675** the first hemicylindrical tubes **421** to be moved toward and away from second hemicylindrical tube **423**. The use of the structure of FIGS. **45** and **46** may be used together to give the ability to provide control, although not as much control as is seen in FIG. **43**. Also seen is an

Referring to FIG. **47**, another possible realization is seen, combining the control mechanisms of selected portions of FIGS. **37-46**, combined with other possible options. An open frame system **691** is seen as having a frame **693** which is either open on at least one side, or which has a side expanded to a distance sufficient to introduce other structures to expand in that direction. Some of the components previously seen include pins **577** and **579** extending through slot **575**. Pins **577** and **579** may have extended vertical and horizontal extent to garner additional stability from the frame **693**, especially where one side is open.

Other structures may be used to insure that neither the first hemicylindrical tube **421** nor the second hemicylindrical tube **423** are able to turn within the frame **573**. Also seen are turn fitting **581**, threaded member **583**, knob **587**, turn fitting **591**, threaded member **593**, and knob **597**. The view of FIG. **47** is from above, and thus the structures most closely correspond to the upper structures seen in FIG. **43** and in FIG. **44**.

As can be seen in FIG. **47**, a four point retractor system can be formed with the components and structures of the foregoing Figures. The first and second hemicylindrical tubes **421** and **423** are shown in the open position. On the longer connector arm of the frame **693**, a side shield **695** is supported. The side shield **695** can derive its ability to hold tissue out of the visual field by being locked down onto the frame **693** in the same manner as a wrench fits a bolt head. In this configuration, the side shield can be inserted into the center of the surgical field and then rotated into position and moved down slightly to lock it into place. On the opposite side from side shield **695** is a retractor **697** which has a flat portion entering the surgical field and which is controlled from a point remote with respect to open frame system **691**. An angled portion **699** turns from the flat portion seen entering the surgical field and extends down into the area between the open first and second hemicylindrical tubes **421** and **423**.

Also seen are a series of small circular structures **701** about the peripheral upper surface of first and second hemicylindrical tubes **421** and **423**. These structures are at least one of embedded fiber optics and ports for accepting fiber optics. The apertures formed in the metal open at a slight angle to the inside of the first and second hemicylindrical tubes **421** and **423** to direct light into the surgical field without producing a back reflection or other scatter. In cases where the fiber optic is permanently affixed, a light ring section can simply be snapped to or placed on the first and second hemicylindrical tubes **421** and **423**. In cases where the apertures are provided, surgery can continue without fiber optics, or a fiber optics set can be added which can range from an illuminated ring (relying on low angle of incidence and snells law) to direct light through the openings which open to the inside of the first and second hemicylindrical tubes **421** and **423** at a low angle of incidence. Intermediary solutions, such as a light ring having a series of short fiber optic members for insertion into the apertures can be used. To facilitate the use of fiber optics, the hemicylindrical tubes **421** and **423** may be made from a composite material in which the fiber optic components may be present during formation of the tube structures. Other material may be used for tubes **421** and **423**, including materials that either transmit light or have portions which transmit light.

As an alternative to the three sided frame **693**, the open portion of the frame could be enclosed by an expandable member **703** which can have any manner of interlock with the three sided frame **693**. One such interlock is illustrated as simply an annular piston dependence where the expandable member **703** includes a smaller tubular insert **705** which fits closely into a matching bore **707** seen in the terminal ends of the three sided frame **693**. The expandable member **703** can be used to lend additional support to the three sided frame **693**, especially forces produced by the threaded members **583** and **593**. The expandable member **703** is also useful to help support the retractor **697** where such provision is made. The main purpose of expandable member **703** is the adjustability to give greater clearance and access. The same adjustability could be had on the side of three sided frame **693** which supports side shield **695**, especially with a more complex mechanism to enable the frame expansion to be locked into place. A locking mechanism for expandable member **703** is not shown so that the drawings may be simplified, but lock ability can be achieved in the same manner as any metal to metal frame construction known in any field of art.

Referring to FIG. **48**, a side view of the side shield **695** is seen. The clearance for locking onto the frame **693** is about the same as the width of the frame **693** so that non rotational fixation can be transmitted along the length of the side shield **695**.

Referring to FIG. **49**, one possible configuration is seen for a variable depth guide **711** which is utilizable with any of the devices seen in FIGS. **37-46** or any other tubular, minimally invasive system. Variable depth guide **711** has a handle **713** controlling a shaft **715**. Shaft **715** has a through bore **717** which is used to insert a guide line or guide pin to help insert any minimal access system seen in the earlier Figures.

a translatable detent ring **719** interacts with a series of detent indentations **721**. The position of the detent ring **719** will correspond to the lengths of the first and second hemicylindrical tubes **421** and **423** with which the variable depth guide **711** is used. Once the practitioner inserts the variable depth guide **711** into any assembly containing a first and second hemicylindrical tubes **421** and **423**, the necessary height can be adjusted so that the tip of the variable depth guide **711** extends just beyond the lower extent of the joined first and second hemicylindrical tubes **421** and **423**. The height is adjusted by forcing the detent ring **719** to the proper detent indentation **721**, and then inserting it into a closely associated first and second hemicylindrical tubes **421** and **423** to form an overall bullet shape for insertion, preferably a guide pin **155**. Once inserted, the variable depth guide **711** is removed. The detent ring **719** carries a frusto-conical surface **723** where it is used with first and second hemicylindrical tubes **421** and **423** having fluted top areas as seen in FIG. **37** and in previous figures. Any mechanism can be used to achieve a detent action, including an internal pressure ring or a spring loaded bar, or protruding ball bearings. The positional stability of the detent ring can be specified by the spring action of the detent member, and should be sufficiently stable to enable deliberate manual fixation with no inadvertent movement occurring even where significant resistance is encountered.

Referring to FIG. **50** is a vertical plan view looking down upon an expandable frame system **751** which uses detents to set the frame size and which uses an angular distribution system. A frame is used as a support and reference point to manipulate a working tube in much the same way as FIGS.

37-47. Expandable frame system **751** enables the user to control the size of the operating theater as needed. Where the task can be accomplished with minimum opening access, such minimum opening is all that needs to be taken. Where greater access is needed, the expandable frame system **751** provides both an expanded work space, and additional surfaces for support of other instrumentation.

As before, the retractor blades are seen as a first hemicylindrical tube **753** having an upper flared portion **755** and a second hemicylindrical tube **757** having an upper flared portion **759**. Each of the first and second hemicylindrical tubes **753** and **757** have two points of variable pivoting attachment.

Hemicylindrical tube **753** has a pivot bar **781** which may be attached somewhat tangentially to the first hemicylindrical tube **753**, or may include a pair of extensions attached to the outside of the first hemicylindrical tube **753**. Likewise, hemicylindrical tube **757** has a pivot bar **783** which may be also attached somewhat tangentially to the first hemicylindrical tube **753** in the same manner.

Pivot bar **781** has circular lands **785** which fit into support fittings **787**. Likewise pivot bar **783** also has circular lands **785** which fit into support fittings **787**. The support fittings **787**, as seen from above, show the lands **785**. In this configuration the lands **785** can be dropped in from above. This is an over-simplified illustration, as some other locking mechanism can be utilized, including ball shape instead of disc shape or other. It would be preferable that the manner of pivoting engagement will firstly enable an ease of assembly and disassembly and secondly provide good stability against dislodgement with respect to any forces experienced when the expandable frame system **751** is in an operational position.

Above the point of pivot of the pivot bars **781** and **783**, each of the first and second hemicylindrical tubes **753** and **757** are fitted with a pivot bearing fitting **791**. The pivot bearing fittings **791** can depend from either the first and second hemicylindrical tubes **753** and **757** or their upper flared portions **755** and **759**. The pivot bearing fittings **791** can be hinge type of ball type, or any other type which will enable the upper part of the first and second hemicylindrical tubes **753** and **757** tp be force moved to pivot them with respect to the pivot fittings **781** and **783** in either direction.

The pivot bearing fitting **791** is engaged by a cooperating fitting **793** which enables the pivot bearing fitting **791** to pivot with respect to the cooperating fitting **793**. The cooperating fitting **793** is moved with a threaded member **795**, having a thumb control wheel as a tilt screw knob **797**. In the drawings of FIGS. **50** and **51**, the fittings **791** are located above the pivot bars **781** and **783**, but they need not be.

In the embodiments of FIGS. **50** and **51** the movement of the axes of the pivot bars **783** are affected by the expansion of a frame support including a first lateral member **801** and a second lateral frame member **803**. The ends of firs and second lateral members **801** and **803** are connected to two telescoping frame members **805** and **807**. Telescoping frame member **805** has a central hinge box **811** which is positioned between a first sleeve **813** and a second sleeve **817**. The central frame section pivotally supports a pair of internal spreading bars, including a first spreading bar **821** which extends within first sleeve **813** and a second spreading bar **823** having a ratchet or detent structure (to be described) which extends within second sleeve **817**.

Although not shown in FIGS. **50** and **51**, the spreading bars **821** and **823** will preferably have an internal gear mesh so that both will preferably have an equal angular displacement with respect to the central hinge box **811**. The articulation within the central hinge box **811** will enable the selection of three angular frames of reference with regard to the surface of a patient, namely the angle of first sleeve **813**, the angle of central hinge box **811**, and the angle of second sleeve **817**. Where other objects, such as retractors, light sources etc have to be anchored, three reference angle surfaces are available.

The spreading bars **821** and **823** are thus axially fixed with respect to the central hinge box **811**, with the spreading bars **821** and **823** axially slidable within the first and second sleeves **813** and **817**. Many mechanisms can be utilized to fix the position of the spreading bars **821** and **823** within the first and second sleeves **813** and **817**. One such mechanism is show schematically in its most rudimentary form in FIG. **38** as including a pivot support **825** which supports a lever **827**. The lever **827** operates against a spring **829** and operates an engagement member **831** with respect to detent structures **833** located on the spreading bars **823**. These structures form a first ratchet stop **835**. Operational depression of the lever **827** disengages the detent structures **833** of the spreading bar **823** to slide within the sleeve **817** and releasing the lever **827** enables the spring **829** to act to cause engagement of the engagement member **831**. With this mechanism, or a similar mechanism, the expansion of the expandable frame system **751** can be controlled, with the expansion of the second lateral frame member **803** away from the central hinge box **811**. Similarly the first lateral member **801** is independently movable away from central hinge box **811** with the use of a mechanism similar to the one shown with respect to the pivot support **825**, lever **827**, spreading bar **823** engagement member **831**, and detent structures **833**.

The detent structures **833** could be made triangular shaped for sliding in one direction with hold against the other direction. A second mechanism similar to the one shown with respect to the pivot support **825**, lever **827**, spreading bar **823** engagement member **831**, and detent structures **833** is omitted from FIGS. **50** and **51** for simplicity. Regardless of the structure, the expandable frame system **751** can be exactly positioned. Other assisted mechanisms can be employed, including a threaded member or a pinion or other device which will give the user mechanical advantage in extending the expandable frame system **751**. Further, the fittings illustrated, including pivot bars **781** & **783** with circular lands **785** and slip fitting into support fittings **787**, as well as the pivot bearing fitting **791** and cooperating fitting **793** suggest that the expandable frame system **751** may be added to the operating theater after the first and second hemicylindrical tubes **753** and **757** have been employed into the surgical opening. This will free the surgeon to position the first and second hemicylindrical tubes **753** and **757** without having to handle the supporting frame members.

Between the other ends of the first lateral member **801** and second lateral frame member **803** the second telescoping frame member **807** also has a central hinge box **811**. Again, the central hinge box **811** which is positioned between a first sleeve **813** and a second sleeve **817**. The central frame section pivotally supports a pair of internal spreading bars, including the first spreading bar **821** within first sleeve **813** and the second spreading bar **823** which extends within second sleeve **817**.

The interfit between the first and second sleeves **813** and **817** and the first and second spreading bars **821** and **823** in both the first and second telescoping frame members **805** and **807** is expected to be of sufficiently tight tolerance so that both of the central hinge box **811** remain directly across from each other. If the latch mechanism supported by the second lateral frame member **803** is released the second lateral frame member **803** should move away from the central frame sections **811**. In other words, one of the central frame sections **811** should not displace to a position other than directly across from each other.

The second telescoping frame member **807** could have the same mechanism as the first telescoping frame members **805**, but a slightly different mechanism is shown in order to emphasize the variability which can be employed with respect to the expandable frame system **751**. A retention housing **837** is attached to second sleeve **817** and houses a lock pin **839** and a spring **841** which urges it int the second sleeve **817** where it lockably interfits with the detent structures **833**. These structures may be collectively referred to as a second ratchet stop **843**. The expansion of the expandable frame system **751**, if properly toleranced will enable the right and left sides to be independently controlled in movement toward and away from the away from the central hinge box **811**. The actuation of one release mechanism will enable balanced displacement of its associated first or second lateral members **801** and **803**.

Movement of the associated first or second lateral members **801** and **803** by one of the latches shown gives a parallel distance separation of the first hemicylindrical tube **753** with respect to the second hemicylindrical tube **757**, regardless of their respective angular positions (assuming no interference). However, the angularity of the first and second hemicylindrical tube **753** and **757** are set by the movement of the threaded member **795**. As such, the expandable frame system **751** enables independent angularity adjustment for the first and second hemicylindrical tube **753** and **757** and independent parallel separation for the first and second hemicylindrical tube **753** and **757** based upon expansion of the frame.

Other features seen in FIGS. **50** and **51** include a support tang **845** and a pair of manipulation sphere projections as spreader projections **847** to assist in manually manipulating the expandable frame system **751**. FIG. **51** illustrates a condition in which the expandable frame system **751** is in an expanded orientation, with first lateral member **801** and second lateral frame member **803** equally expanded from central hinge box **811**. Either of the first and second lateral members **801** and **803** could have been extended from the central hinge box **811**. This feature gives the surgeon the flexibility to adjust the positioning of the central hinge box **811**. The central hinge box **811** may also have support structures for other instrumentation, including bores **849** in the central hinge box **811** such as a bookwalter support (to be shown). Bores **849** can be used for locational registry or for threaded attachment. A bookwalter device is especially useful for supporting an additional retractor, in addition to the first and second hemicylindrical tubes **753** and **755**.

Referring to FIG. **52**, a side view of the system of FIGS. **50-51** illustrates further details. The angle of the incline of the upper flared portions **755** and **759** are illustrated. A scale **851** helps the surgeon to ascertain the depth to which the first and second hemicylindrical tubes **753** and **755** are inserted into the patient (with the additional consideration of any further extension which may be added to the first and second hemicylindrical tubes **753** and **755**).

One possible configuration for the first and second hemicylindrical tubes **753** and **755**, include the use of an upper tube portions along with a lower extension. The scale **851** could also be utilized, in conjunction with the extension to indicate depth. A notch **853** can be used as a reference surface to engage an extension. Another surface can include a raised portion or depressed portion matched to an extension (as will be shown) in each of the first and second hemicylindrical tubes **753** and **755**.

FIG. **53** illustrates a double pivot hinge fitting within the central hinge box **811**. A pair of threaded members **861** extend into machined spaces within central hinge box **811** and hold the spreading bars **821** and **823** into a close proximate location such that the complementary gear teeth **863** located on the abutting ends of the spreading bars **821** and **823** intermesh with each other. This arrangement insures that the angular displacement of the spreading bars **821** and **823** with respect to the central hinge box **811** will be equi-angular. This is shown in FIG. **54** where the angle γ on both sides indicates equi angular displacement.

Referring to FIG. **55**, a top view of the central hinge box **811** illustrates a bookwalter retractor device **871** mounted on the upper surface of the central hinge box **811**. The bookwalter device has a central through bore **873** through which a retractor rail or extension may pass. Typically the retractor extension (not shown) will have a series of detents similar to the detents **833** seen in FIG. **53**. As the detents emerge from the through bore **873**, they are engaged by a pivoting latch **875** which operates under urging force from a spring **877**. A turnbuckle or other force control structure would enable operation of a gear mechanism to move any type of "east west" retractor blades towards or away from the center.

Referring to FIG. **56**, a plan view is shown of a remote force retraction system employing many of the structures seen in FIGS. **50-55**, but with a remote force system such as disclosed and shown in U.S. Pat. No. 4,747,394, to Robert S. Watanabe, and incorporated by reference herein. The technique of application of remote force to leave the surgical field open as applied to the expandable frame system **751** is seen as an open minimally invasive expansion system **901**. At the surgical field, many of the components previously seen have the same numbering.

A pinion box **903** carries a (removable) key insertable gear **905** seen inside an aperture **907** having teeth **911** which engage a linear gear **913** on a first rack **915**, and which also engage linear gear **917** on a second rack **919**. Rack **915** is fixedly attached to a first main support **921** while rack **919** is fixedly attached to a second main support **923**. As the gear **905** is turned clockwise, the rack **915** freely feeds through an aperture **931** (seen in dashed line format) in second main support **923**, through the pinion box **903** and pushes first support **921** father away from the pinion box **903**. At the same time, the gear **905** pushes the rack **919** freely feeds through an aperture **933** (seen in dashed line format) in first main support **921**, through the pinion box **903** and pushes second support **923** farther away from the pinion box **903**.

The result is that two strong support members, namely first support **921** and second support **923** are being forced away from each other remotely, by the turning of the key insertable gear **905**. Note that the areas on either side of the first and second hemicylindrical tubes **753** and **755** are clear to enable other structures to be employed, either unsupported, or independently supported, or possibly supported from structures which support first support **921** and second support **923**.

A ratchet latch lever **935** is mounted is mounted to pivot with respect to first support **921** by the action of a spring **937**. The ratchet latch lever **935** is fork shaped to fit around the tip fixed end of rack **914** and to actuate an internal latch **939** which operates within the first support **921** between the first rack **915** and second rack **919**.

Also seen is a hinge **941** on first support **921**, and a hinge **943** on second support **923**. The hinges **941** and **943** should preferably have the same angular range and would ideally be from about zero degrees (flat) to about fifteen degrees down with the hinges **941** and **943** rising to form the apex. The hinges **941** and **943** permit the lateral force components to be angularly sloped down, or draped to provide an angled working presentation, and to take up less lateral space in the same plane as the working area. Beyond the hinges **941**, the first support **921** is connected to a first extended support **945** while the second support **923** is connected to second extended support **947**.

Both the first and second extended supports **945** and **947** include angular extensions **949** which support the support fittings **787** and other structures previously shown. The first and second extended supports **945** and **947** also support tilt screw knob **797** and manipulation sphere projections as spreader projections **847**. The support details for the first and second hemicylindrical tubes **753** and **755** is essentially the same as was shown for FIGS. **50** & **51**.

In addition, an optional pair of tilt fittings enable the first and second extended supports **945** and **947** to tilt where it may be more advantageous to locate open minimally invasive expansion system **901** over portion of a patient's body which is angled. A first tilt adjustment fitting **951** can be used to provide tilt to the main extent of first extended support **945**, while a second tilt adjustment fitting **953** can be used to provide tilt to the main extent of second extended support **947**. Typically the first and second tilt adjustment fittings **951** and **953** will be used to set the tilt before an operation begins. As to both of the first and second tilt adjustment fittings **951** and **953**, a support plate **955** is rigidly supported by the portion of the respective first and second extended supports **945** and **947** nearest the hinges **941**. The support plate **955** supports a retention housing **837**. The retention housing includes a lock pin **839** and a spring **841** which urges it through apertures of the support plate **955** and across to a selector plate **957**. As to both of the first and second tilt adjustment fittings **951** and **953**, the selector plate **957** is rigidly supported by the portion of the respective first and second extended supports **945** and **947** on the other side of the respective first and second tilt adjustment fittings **951** and **953**.

Although shown in somewhat schematic view, a tilt pin **961** joins portions of first extended support **945** rigidly while enabling the tilting of the portion of the first extended supports **945** on one side of the first tilt adjustment fitting **951** to pivot with respect to the portion of the first extended supports **945** on the other side of the first tilt adjustment fitting **951**. Likewise, a tilt pin **963** joins portions of second extended support **947** rigidly while enabling the tilting of the portion of the second extended supports **947** on one side of the second tilt adjustment fitting **953** to pivot with respect to the portion of the second extended supports **947** on the other side of the second tilt adjustment fitting **953**. In reality, in order to transmit the force rigidity, more complex internal fittings may be utilized. The support plate **955** and selector plate **957** are simple mechanical mechanisms which are located far enough off the axis of pivot to enable selection of a number of angular positions.

Other structures can be supported from the both the first and second extended supports **945** and **947**. A pair of slot openings **965** at the far ends of the first and second extended supports **945** and **947** can support additional instrumentation. In addition, the first and second extended supports **945** and **947** include structures **965** which may be apertures or projections or other structures which will enable support to be derived for other retractors. A cross support **971** supports a mechanical housing **973** through which a linear gear **975** can extend. A retractor **976** (which can be of any type) is attached to one end of the linear gear **975**. A hand wheel **977** operates a gear **979** which moves the linear gear **975** through the housing **973**. This assembly is a first cross supported retractor set **981**. A second cross supported retractor set **983** is also shown. This gives the surgical practitioner good control and leverage to operate the "north-south" retractors.

An illustration of an extension previously mentioned is illustrated in FIG. **57** which illustrates a top view of a hemicylindrical extension **991** standing alone. Hemicylindrical extension **991** may have several pair of inwardly directed members **993** (or a single large inwardly directed member **993**) for engagement against the notches **853** seen in FIG. **52**. An inwardly directed angled "snap" protrusion **995** springs into a matching opening on either of the first and second hemicylindrical tubes **753** and **755**. The hemicylindrical extension **991** will fit on the outside of the matching first or second hemicylindrical tubes **753** and **755** and the force on the hemicylindrical extension **961** is expected to be inward at its lower extent during spreading.

Referring to FIG. **58**, a side semi-sectional view is shown. A lower portion of first hemicylindrical tube **753** having groove **853**, and a slot **997** is seen in a sectional view. Adjacent the semi section hemicylindrical tube **753** is the hemicylindrical extension **991** in an attached position. The upper end of he notch **853** fixes against up motion, and the slot **997** fixes against down motion when it engaged with inwardly directed angled "snap" protrusion **995**. A stable support relationship is shown.

Referring to FIG. **59**, a view looking down into the inside of the combination of the first hemicylindrical tube **753** and hemicylindrical retractor tube extension **99** of FIGS. **57** and **58**. It can be seen how the large inwardly directed members **993** wrap around the groove **853** and can be slid upwardly until the inwardly directed angled "snap" protrusion **995** engages.

Referring to FIG. **60**, a view looking down onto the outside of the combination of the first hemicylindrical tube **753** and hemicylindrical retractor tube extension **99** of FIGS. **57-59** is seen. In addition, the pivot bar **781** with circular lands **785** are also seen below the pivot bearing fitting **791**, for reference. The large inwardly directed member **993** is partially shown in dashed line format. The bottom of the hemicylindrical extension **991** may be of any shape.

While the present system has been described in terms of a system of instruments and procedures for facilitating the performance of a microscopic lumbar diskectomy procedure, one skilled in the art will realize that the structure and techniques of the present system can be applied to many appliances including any appliance which utilizes the embodiments of the instrumentation of the system or any process which utilizes the steps of the inventive system.

Although the system of the invention has been derived with reference to particular illustrative embodiments thereof, many changes and modifications of the system **31** may become apparent to those skilled in the art without departing from the spirit and scope of the inventive system. Therefore, included within the patent warranted hereon are all such changes and modifications as may reasonably and properly be included within the scope of this contribution to the art.

What is claimed:

1. A minimal incision maximal access expansion system comprising:

a first main support;

a second main support;

a remote lateral force assembly attached to and located between said first main support and said second main support, said remote lateral force assembly being configured to controllably move said first main support apart from said second main support;

a first hemicylindrical member having at least a first upper pivot axis support providing an upper first hemicylindrical member axis of rotation nearer a proximal end of said first hemicylindrical member and at least a first lower pivot axis support providing a lower first hemicylindrical member axis of rotation nearer a distal end of said first hemicylindrical member, said first lower pivot axis support pivotally supported from said first main support, and said first upper pivot axis support force displaceable from said first main support, the first hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis;

a second hemicylindrical member having at least a second upper pivot axis support providing an upper second hemicylindrical member axis of rotation nearer a proximal end of said second hemicylindrical member and at least a second lower pivot axis support providing a lower second hemicylindrical member axis of rotation nearer a distal end of said second hemicylindrical member, and oriented with respect to said first hemicylindrical member to form a tube shape when brought into close proximity to said first hemicylindrical member, the second hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis, said second lower pivot axis support pivotally supported from said second main support, and said second upper pivot axis support force displaceable from said second main support, said remote lateral force assembly providing clearance displaced from said first and second hemicylindrical members to facilitate introduction of other structures proximal said first and said second hemicylindrical members, said first hemicylindrical member and said second hemicylindrical member being independently pivotable with respect to each of said first and second main supports and with respect to other said hemicylindrical member;

first and second tiltable members provided on said first and second main supports, respectively, said first and second tiltable members configured to tilt said first and second main supports;

a first threaded force member supported by a first internal thread supported within said first main support and having an end terminating adjacent said first upper pivot axis support of said first hemicylindrical member; and

a second threaded force member supported by a second internal thread supported within said second main support and having an end terminating adjacent said second upper pivot axis support of said second hemicylindrical member.

2. The minimal incision maximal access expansion system as recited in claim **1** wherein said first and said second main supports each have a hinge between said remote lateral force assembly and each of said respective first and said second hemicylindrical members.

3. The minimal incision maximal access expansion system as recited in claim **1** and wherein said first and said second hemicylindrical members have a groove partially along a first and a second edge and a slot opening spaced apart from said first and said second edges and further comprising:

a first extension member attached to said first hemicylindrical member, said first extension member including a first inwardly directed member adjacent said first edge of said first hemicylindrical member and a second inwardly directed extension member adjacent said second edge of said first hemicylindrical member, said first extension member having an angled protrusion for fitting within said slot opening of said first hemicylindrical member; and

a second extension member attached to said second hemicylindrical member, said second extension member including a first inwardly directed member adjacent said first edge of said second hemicylindrical member and a second inwardly directed extension member adjacent said second edge of said second hemicylindrical member, said second extension member having an angled protrusion for fitting within said slot opening of said second hemicylindrical member.

4. The minimal incision maximal access expansion system as recited in claim **1** and wherein said first and said second hemicylindrical members have a top flared portion.

5. A minimal incision maximal access expansion system comprising:

a first main support having a pair of first legs;

a second main support having a pair of second legs;

a remote lateral force assembly attached to and located between said pair of first legs and said pair of second legs, said remote lateral force assembly being configured to controllably move said first main support apart from said second main support;

a first hemicylindrical member located between said pair of first legs, said first hemicylindrical member having at least a first upper pivot axis support providing an upper first hemicylindrical member axis of rotation nearer a proximal end of said first hemicylindrical member and at least a first lower pivot axis support providing a lower first hemicylindrical member axis of rotation nearer a distal end of said first hemicylindrical member, said first lower pivot axis support pivotally supported from said first main support, and said first upper pivot axis support force displaceable from said first main support, the first hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis;

a second hemicylindrical member located between said pair of second legs, said second hemicylindrical member having at least a second upper pivot axis support providing an upper second hemicylindrical member axis of rotation nearer a proximal end of said second hemicylindrical member and at least a second lower pivot axis support providing a lower second hemicylindrical member axis of rotation nearer a distal end of said second hemicylindrical member, and oriented with respect to said first hemicylindrical member to form a tube shape when brought into close proximity to said first hemicylindrical member, the second hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis, said second lower pivot axis support pivotally supported from said second main support, and said second upper pivot axis support force displaceable from said second main support, said remote lateral force assembly providing clearance displaced from said first and second hemicylindrical members to facilitate introduction of other structures proximal said first and said second hemicylindrical members;

first and second tiltable members provided on said first and second main supports, respectively, said first and second tiltable members configured to tilt said first and second main supports;

a first threaded force member supported by a first internal thread supported within said first main support and having an end terminating adjacent said first upper pivot axis support of said first hemicylindrical member; and

a second threaded force member supported by a second internal thread supported within said second main support and having an end terminating adjacent said second upper pivot axis support of said second hemicylindrical member.

6. The minimal incision maximal access expansion system as recited in claim, **5** wherein said first and said second main supports each have a hinge between said remote lateral force assembly and each of said respective first and said second hemicylindrical members.

7. The minimal incision maximal access expansion system as recited in claim, **5** and wherein said first and said second hemicylindrical members have a groove partially along a first and a second edge and a slot opening spaced apart from said first and said second edges and further comprising:

a first extension member attached to said first hemicylindrical member, said first extension member including a first inwardly directed member adjacent said first edge of said first hemicylindrical member and a second inwardly directed extension member adjacent said second edge of said first hemicylindrical member, said first extension member having an angled protrusion for fitting within said slot opening of said first hemicylindrical member; and

a second extension member attached to said second hemicylindrical member, said second extension member including a first inwardly directed member adjacent said first edge of said second hemicylindrical member and a second inwardly directed extension member adjacent said second edge of said second hemicylindrical member, said second extension member having an angled protrusion for fitting within said slot opening of said second hemicylindrical member.

8. The minimal incision maximal access expansion system as recited in claim, **5** and wherein said first and said second hemicylindrical members have a top flared portion.

9. A minimal incision maximal access expansion system comprising:

first and second main supports each including a first portion and a second portion;

a remote lateral force assembly attached to and located between said first main support and said second main support, said remote lateral force assembly being configured to controllably move said first main support apart from said second main support;

a first hemicylindrical member having at least a first upper pivot axis support providing an upper first hemicylindrical member axis of rotation nearer a proximal end of said first hemicylindrical member and at least a first lower pivot axis support providing a lower first hemicylindrical member axis of rotation nearer a distal end of said first hemicylindrical member, said first lower pivot axis support pivotally supported from said first main support, and said first upper pivot axis support force displaceable from said first main support, the first hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis;

a second hemicylindrical member having at least a second upper pivot axis support providing an upper second hemicylindrical member axis of rotation nearer a proximal end of said second hemicylindrical member and at least a second lower pivot axis support providing a lower second hemicylindrical member axis of rotation nearer a distal end of said second hemicylindrical member, and oriented with respect to said first hemicylindrical member to form a tube shape when brought into close proximity to said first hemicylindrical member, the second hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis, said second lower pivot axis support pivotally supported from said second main support, and said second upper pivot axis support force displaceable from said second main support, said remote lateral force assembly providing clearance displaced from said first and second hemicylindrical members to facilitate introduction of other structures proximal said first and said second hemicylindrical members, said first hemicylindrical member and said second hemicylindrical member being independently pivotable with respect to each of said first and second main supports and with respect to other said hemicylindrical member; and

first and second tiltable members coupling said first and second portions of respective first and second main supports, said first and second tiltable members configured to tilt said first and second main supports, said first and second tiltable members each including a support plate secured to said first portion of respective first and second main supports, a selector plate secured to said second portion of respective first and second main supports, and a lock pin disposed on said support plate, said support plate and said selector plate being longitudinally opposing each other, at least one of said support plate and selector plate configured to pivot with respect to the other, said lock pin configured to secure the relative position of said support plate and said selector plate.

10. The minimal incision maximal access expansion system as recited in claim **9**, wherein said first portions are tiltable relative to said second portions, thereby defining an acute angle therebetween.

11. The minimal incision maximal access expansion system as recited in claim **9**, wherein said first and second tiltable members are disposed adjacent said remote lateral force assembly.

12. A minimal incision maximal access expansion system comprising:

a first main support having a pair of first legs;

a second main support having a pair of second legs;

a remote lateral force assembly attached to and located between said pair of first legs and said pair of second legs, said remote lateral force assembly being configured to controllably move said first main support apart from said second main support;

a first hemicylindrical member located between said pair of first legs, said first hemicylindrical member having at least a first upper pivot axis support providing an upper first hemicylindrical member axis of rotation nearer a proximal end of said first hemicylindrical member and at least a first lower pivot axis support providing a lower first hemicylindrical member axis of rotation nearer a distal end of said first hemicylindrical member, said first lower pivot axis support pivotally supported from said first main support, and said first upper pivot axis support force displaceable from said first main support, the first hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis;

a second hemicylindrical member located between said pair of second legs, said second hemicylindrical member having at least a second upper pivot axis support providing an upper second hemicylindrical member axis of rotation nearer a proximal end of said second hemicylindrical member and at least a second lower pivot axis support providing a lower second hemicylindrical member axis of rotation nearer a distal end of said second hemicylindrical member, and oriented with respect to said first hemicylindrical member to form a tube shape when brought into close proximity to said first hemicylindrical member, the second hemicylindrical member being pivotal about the upper pivotal axis and the lower pivotal axis, said second lower pivot axis support pivotally supported from said second main support, and said second upper pivot axis support force displaceable from said second main support, said remote lateral force assembly providing clearance displaced from said first and second hemicylindrical members to facilitate introduction of other structures proximal said first and said second hemicylindrical members;

first and second tiltable members provided on said first and second main supports, respectively, said first and second tiltable members configured to tilt said first and second main supports; and

a pair of opposing retractor blades disposed between said first and second main supports and offset from said first and second hemicylindrical members, wherein said pair of opposing retractor blades define a first axis and said first and second hemicylindrical members define a second axis, said first axis and said second axis being substantially orthogonal to each other.

13. The minimal incision maximal access expansion system as recited in claim **12**, further comprising a pair of cross supports supported substantially orthogonally on said first and second main supports, said pair of opposing retractor blades adjustably supported on respective pair of cross supports.

14. The minimal incision maximal access expansion system as recited in claim **13**, wherein said first and second hemicylindrical members are interposed between said pair of cross supports.

15. The minimal incision maximal access expansion system as recited in claim **13**, further comprising a pair of adjustment bars, each of said pair of adjustment bars being coupled to respective pair of opposing retractor blades and adjustably supported on respective pair of cross supports such that said pair of opposing retractor blades may be adjustably moved toward and away from each other.

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